DIGITAL VOICE SYSTEMS, INC.

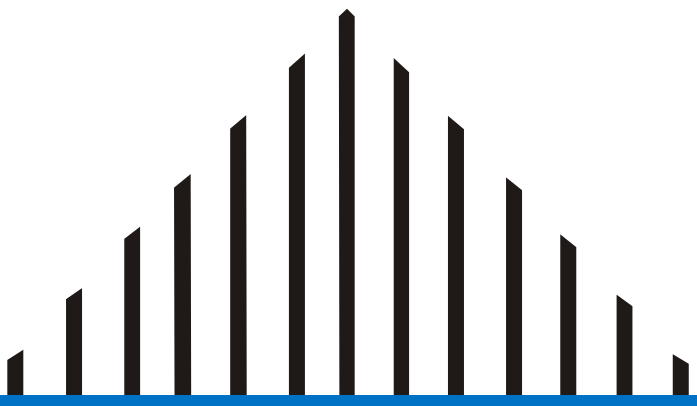
The Speech Compression Specialists

Net-2000-VCU
Voice Codec Unit

Users Manual

Version **4.0**

December, 2013



DVSI Confidential Proprietary

Net-2000™ VCU
Users Manual
Version **4.0**
December, 2013

(The most up to date version of the manual is always available at www.dvsinc.com)

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1 Net-2000™ Voice Codec Unit Introduction

The Net-2000™ Voice Codec Unit (VCU) incorporates Digital Voice Systems, Inc. (DVSI) latest advancement in voice compression technology to bridge analog speech I/O to an Ethernet network. There are various versions of the Net-2000™-VCU that support a variety of vocoders used in voice compression digital communication systems.

The basic operation and control of Net-2000™-VCU is the same for all versions. This manual includes information on all versions of the Net-2000™-VCU. Differences between versions are separated so that the user needs only to refer to the sections that pertain to the specific Net-2000™ VCU purchased.

The Net-2000™-VCU contains several interfaces for flexibility in speech input and output including Ethernet and RS-422 as a channel data interfaces. The Net-2000™-VCU speech I/O can operate in full duplex for real time communication or in half duplex mode voice recording or other storage applications. The speech I/O is easily managed with the Net-2000™-VCU built-in web server control.

1.1 Features

- ◊ Real-time, full-duplex communications via the Ethernet interface to another Net-2000™-VCU unit.
- ◊ A built-in web server for easy selection and control of the audio I/O
- ◊ The Net-2000™-VCU's RS-232 serial port can be used as a console terminal to allow low-level system setup.
- ◊ The Net-2000™-VCU can handle information from a DHCP server when available on a Local Area Network (LAN).
- ◊ Encode/Decode files across a LAN to and from a PC
- ◊ The embedded user interface allows the operation software to be field upgradeable.
- ◊ Both voice and channel data can be transmitted over the Ethernet interface at the same time.

1.2 Interfaces

To meet a wide variety of communication system requirements the Net-2000™-VCU contains three interfaces for speech input and output and two for channel data. The Net-2000™-VCU's analog interfaces includes a 4-wire, a handset and a 2-wire for input and output of uncompressed speech. Control of these interfaces are easily managed with the Net-2000™-VCU's built-in web server.

The Net-2000™-VCU provides a RS-422 interface and 10Base- Ethernet interface as a channel connection. The RS-422 allows two Net-2000™-VCUs to be connected together. By providing both an asynchronous or synchronous connecting the Net-2000™-VCU offers the flexibility of connecting to some other RS-422 device. Using the 10Base- Ethernet interface the Net-2000™-VCU can also be connected directly to a Local Area Network (LAN). This configuration can be used to create a real-time full duplex Voice Over Internet Protocol (VOIP) Ethernet based vocoder communication system between two Net-2000™-VCUs. Alternatively, the Net-2000™-VCU can Loopback the VOIP information back to itself for voice monitoring and evaluation applications.

When two Net-2000™-VCU communicate, each converts the input analog speech into digital speech samples, encodes the speech using the selected vocoder mode and then sends the compressed bit stream out over Ethernet as UDP packets or RS-422. Simultaneously, the compressed bit stream of UDP packets from the other Net-2000™-VCU are read in from the selected interface and decoded back in to digital speech samples. The decoded samples are converted back into analog speech via the AIC-10 codec whose output is sent to both the handset and line-level output connections.

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1.3 Net-2000™-VCU modes of operation

The Net-2000™-VCU provides the user with two modes of operation VOIP Mode and File Mode. To provide full duplex real-time communication, the Net-2000™-VCU can channel the compressed bit stream through either the RS-422 or the Ethernet interfaces to another Net-2000™-VCU.

Alternatively, in File mode the Net-2000™-VCU can Encode/Decode files stored on a PC on the LAN for non-real-time testing and evaluation. The Net-2000™-VCU remains in an idle state until it gets a command to start and stop processing (encoding and/or decoding) data that is being sent.

1.4 Control

When connected on a LAN — any PC on the network can use a standard web browser to control the Net-2000™-VCU through the use of a PC web browser. The user-friendly web pages built-into the Net-2000™-VCUmake it easy to select analog audio interfaces, select the vocoder mode and to establish real-time, full-duplex communication across the Ethernet connection. In addition to the control, the web pages display information about network settings, operating mode and system status. Since the Net-2000™-VCUuses Ethernet, its web page can even be accessed over a wireless network through a wireless notebook or tablet PC.

The Net-2000™-VCUcan also be controlled via PC connected to the RS-232 interface. Connecting to the RS-232 interface allows for both low level set-up of the NET-2000™-VCU and for control using ASCII commands. Input and output gain settings for the voice codec can be also specified.

1.5 Protocol

The Net-2000™-VCU uses DVSI's own UDP interface described in Section 4. This allows users to develop their own application controls and user interfaces for an endless array of customized applications.

Before using the Net-2000™-VCU, read through this user's manual in its entirety.

2 Net-2000™ VCU Installation

The Net-2000™-VCU hosts a variety of inputs and outputs that provide flexibility in system integration. The Net-2000™-VCU is designed to be controlled through an Ethernet Interface or an RS-232 serial interface with the communication channel interface using the RS-422 serial port or the Ethernet network. This manual assumes that the user has a working networked PC before the Net-2000™-VCU is installed.

2.1 Set Up

Initial set-up of the Net-2000™-VCU is fast and straightforward. The Ethernet interface is equipped to handle IP address information from a DHCP server making network installation routine. Alternatively, the RS-232 serial port can be used via telnet as a console terminal to allow low-level network setup.

2.2 Net-2000™-VCU Connections

See VCU Specifications for more detailed technical information about each of the connections.

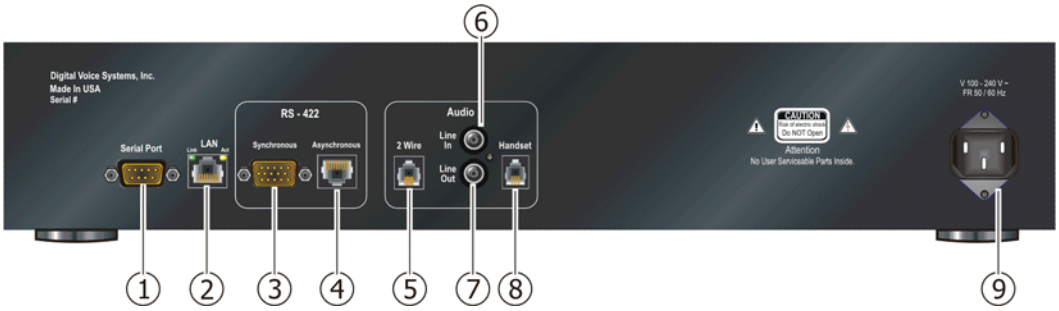

Figure 1 Net-2000™-VCU Rear Panel

Rear Panel Connections		
Item No.	Name	Connector Type
1	Serial Port	DE9s
2	LAN	RJ-45
3	RS-422 Synchronous	DB-15HD
4	RS-422 Asynchronous	RJ-45
5	2 Wire I/O	RJ-11
6	Analog Line In	RCA Jack
7	Analog Line Out	RCA Jack
8	Handset	RJ-11
9	AC Line In	Power Cord Receptacle

Table 1 Rear Panel Connectors

In order to install the Net-2000™-VCU connections must be made to a voice audio source and output, channel communications and control. In Target IP Mode, the Net-2000™-VCU can be connected to another Net-2000™-VCU located anywhere on the LAN. This configuration can support a real-time, full-duplex channel over Ethernet connection. This mode can be controlled via the built-in web page.

2.2.1 Connecting AC Power

The Net-2000™-VCU unit will automatically adjust to both European and US AC line voltage levels. There are no user settings. Just plug in the AC power cord provided into the AC receptacle on the back of the unit (See Figure 1 Net-2000™-VCU Rear Panel -- item 9) and plug the other end into an AC power outlet.

2.2.2 Voice Audio I/O Connections

2.2.2.1 4-Wire

Connecting the Net-2000™-VCU to analog audio components is fairly self explanatory. A typical connection would be to connect the audio output of an audio component such as a Mic, a Digital Tape, player or even a PC sound card output to the Analog Input jack of the Net-2000™-VCU (audio cables not included). Next connect the Analog Output jack of the Net-2000™-VCU to an amplifier or Audio In jack on a PC sound card.

2.2.2.2 Handset

If the handset connection is to be used instead of the 4-wire interface, connect the standard telephone handset that was included with the unit to connect to the RJ11 handset connector. This handset has a cord (also included) that is about a foot long (when not stretched) to help reduce noise from being introduced into the voice signal.

2.2.2.3 2-Wire

The Net-2000™-VCU can be connected to a standard North American POTS line through its 2-wire interface. The 2-wire interface is designed to pick-up the line and be ready to accept analog voice to be encoded and sent across the designated channel. With the wait on ring feature the Net-2000™-VCU will automatically answer the line when it receives a call instead of having to keep the line open all the time.

2.2.3 Channel Communication

2.2.3.1 Ethernet

The Net-2000™-VCU implements this channel data interface using a special protocol designed by DVSI. This UDP streaming mode allows for full-duplex communication to another Net-2000™-VCU box in real time. To run in this mode the operator selects the voice interface (4-Wire, handset, or 2-Wire) and the Ethernet communications channel interface. When running in VOIP Mode the VCU encodes a frame of speech from the specified voice interface and implements a protocol to stream a packet containing a decode command and encoded data to the communications channel interface. At the same time the VCU expects to receive packets from the communications channel interface that contains a decode command and encoded data. The VCU decodes and sends this continuous stream to both the handset and line-out speech outputs.

In File Mode the Net-2000™-VCU responds to incoming voice packets by encoding the voice data in them and transmitting a channel data packet to the sender, and to incoming channel data packets by decoding them and transmitting synthesized voice data packets to the sender. Only one user can access the VCU at a time in File Mode. Transmitting data packets to the VCU from more than one source will produce undesired results.

2.2.3.2 Connecting the Ethernet Network

Make sure the Ethernet cable is connected to the Ethernet port in the back of the NET-2000™-VCU before applying AC power. Note that if you are going to use a direct Ethernet connection from your PC to the NET-2000™-VCU you should use a crossover cable. If your NET-2000™-VCU is connected to a hub, a straight-through Ethernet cable should be used.

The VCU has a 10 Mbps Ethernet interface for network communication. It can operate on a 100 Mbps LAN when connected to a 10/100 Ethernet hub or router. The default network configuration for the VCU assumes that a DHCP server is available on the LAN to provide it with valid network address information. If a DHCP server is not available on the LAN, static IP address information will need to be entered via the serial port in order to access the VCU over the network.

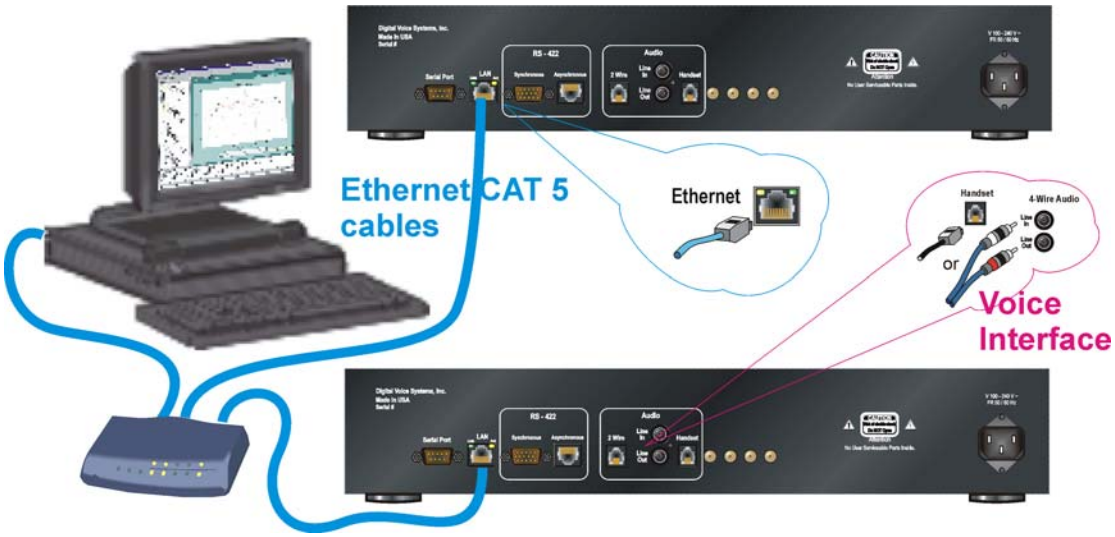

Figure 2 Connecting to an Ethernet Network

2.2.3.3 RS-422

The Net-2000 VCU also provides a RS-422 interface as a communications channel between two VCU units or some other device. The RS-422 interface follows industry standards of differential I/O can be used as either a Asynchronous or Synchronous connection depending on the communication requirements. Both RS-422 interfaces use the same packet protocols as the Ethernet interface as described in 6 Interface Protocol.

The Synchronous RS-422 connection is available on the HD-15 connector located on rear panel of the Net-2000™-VCU and provides the data clock and 8 bit frames. For pinout detail see Section 5 Table 56 RS-422 Synchronous Serial Port Pin Outs

The Asynchronous RS-422 connection is available on the RJ45 connector located on rear panel of the Net-2000™-VCU and provides the data only in a 8,none, 1 format. . For pinout detail see Section 5 Table 57 RS-422 Asyncronous Serial Port Pin Outs.

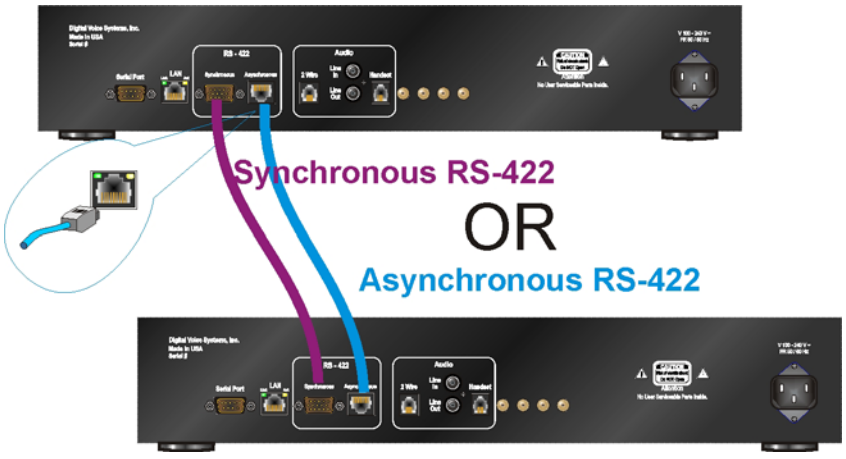

Figure 3 Connect two Net-2000™-VCU via RS-422

2.2.3.4 Connecting to RS-232

The RS-232 serial port located on the back of the Net-2000™-VCU unit provides low level set-up functions. The interface itself consists of a simple command/response ASCII text protocol. You can use a terminal or terminal emulator on a personal computer to type commands at a keyboard as your user interface.

To connect the serial interface, to a Terminal or PC plug a straight-through modem cable (see pin outs in Table 55 Serial Port Pin Outs) into the serial port DE-9s connector and plug the other end into your terminal (or one of the serial ports on your PC if you are using an emulator). Set the terminal as shown in Table 2 Serial Port Terminal Set-up.

2.3 Rack Mount Installation

When a rack mount kit is purchased with the Net-2000™-VCU the assembly is installed at the factory prior to shipping. If the rack mount, needs to be removed there are three flat head Philips screws on each side that secures the rack mount plate to the Net-2000™-VCU chassis as shown below. To avoid scratching the sides of the Net-2000™-VCU when removing the rack plate push down on the front of the plate so that it slips out from underneath the unit. When re-installing the rack mount slip it up from underneath and push it back to be flush with front face. Use the same six screws to secure the rack mount back on the chassis.

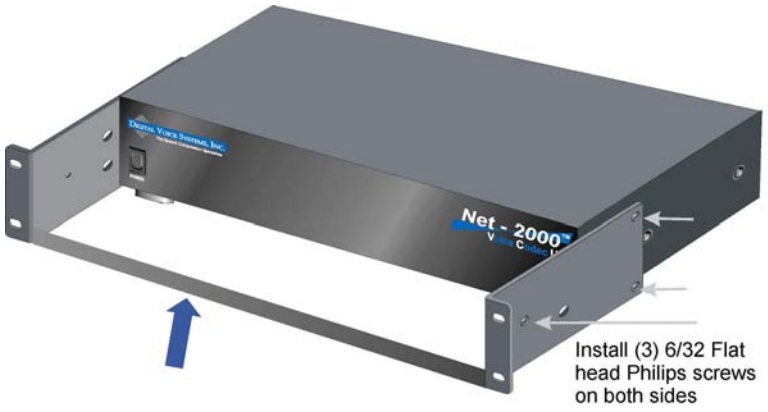

Figure 4 Rack Mount Installation

2.4 VCU Front Panel

Figure 5 Net-2000™-VCU Front Panel

2.4.1 Power On Switch

The Net-2000™-VCU's power is turned ON /Off through the switch on the left side of the front panel. Press the top of the switch (I) to turn ON. Press the bottom of the switch (0) to turn OFF. When powering off the unit always wait a few seconds before turning the unit back on.

2.5 Initial Set-up – (RS-232 Serial Connection)

The RS-232 interface is used for command line style set-up. It is used when the Net-2000™-VCU is installed on a network where there is no DHCP Server or when the user wants to customize the network configuration.

Serial Port Settings	
Bits per second:	9600
Data bits:	8
Parity:	None
Stop bits:	1
Flow control:	None

Table 2 Serial Port Terminal Set-up

Note:
The Ethernet MAC address and default hostname of the VCU is derived from the serial number of the VCU. The MAC address will begin with 00:01:FD followed by the last six digits of the serial number. The hostname is NET2K followed by the last four digits of the serial number. For example, if the last six digits of the serial number are 301234, the MAC address is 00:01:FD:30:12:34 and the hostname is NET2K1234.

When no DHCP server is available on a LAN the VCU's RS-232 serial port can be used as a console terminal for low-level network setup. With the serial cable connected and the terminal running type a few carriage returns from the PC's keyboard. The Net-2000™-VCU will respond with the console prompt as shown below:

adsh>

At the adsh prompt the VCU's network settings can be configured or changed using the terminal console command "network" as follows:

adsh>network [-dhcp] [-h hostname] [-w workgroup] [-i ipaddress] [-m netmask] [-g gateway] [-n nameserver][-d domainname]

The arguments to the network command are described below:

Arguments	Use	Result
-dhcp	when DHCP is available on LAN	DHCP is enabled
-h	anytime	Sets the hostname of the VCU
-w		Sets the Windows workgroup of the VCU
-i	use only when DHCP is disabled	Sets the static IP address
-m		Sets the IP address of the netmask
-g		Sets the IP address of the gateway
-n		Sets the IP address of the nameserver
-d		Sets the domain name of the VCU.

Table 3 DHCP Set-up command Arguments

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The following command example results are shown in the table below

adsh>network –h net2k1234 -w lab -i 192.168.1.100 -m 255.255.255.0 -g 192.168.1.250 -n 192.168.1.1 -d domain.com

Arguments	VCU Result	Example
	DHCP is NOT enabled	
-h	HOSTNAME	net2k1234
-w	Windows WORKGROUP	lab
-i	STATIC IP address	192.168.1.100
-m	NETMASK IP address	255.255.255.0
-g	GATEWAY IP address	192.168.1.250
-n	NAMESERVER IP address	192.168.1.1
-d	VCU DOMAIN NAME	domain.com

Table 4 DHCP Setup Example

NOTE: Do not mix the -dhcp argument with the -i -m –d -g -n arguments.

Use the -i -m -g -n and -d options to set up a static IP address. The argument following the -i -m -g and -n options should in the form of a dotted IP address (e.g. “192.168.0.1”). If a DHCP server becomes available at a later time, it can be enabled by issuing the network command with the –dhcp plus the –w [workgroup] and –h [hostname} arguments as show in the following command example.

adsh>network -dhcp –w[workgroup] -h[hostname]

After setting or changing the network settings, the VCU must be rebooted by typing “shutdown” at the console terminal adsh> prompt.

adsh>shutdown

3 Net-2000™ VCU Control

The Net-2000™-VCU may be set-up from the serial RS-232 interface and controlled through the use of the built-in web server. Both of these interfaces may be used and connected at the same time to provide the flexibility required to integrate to most system configurations.

Connecting to the RS-232 interface allows for low level set-up of the NET-2000™-VCU. When connected on a LAN—any PC on the network can use a standard web browser to configure the unit's mode of operation, I/O interfaces and selection of vocoder mode. Input and output gain settings for the voice codec can be also specified.

In addition to the control, the web pages also display information about network settings, operating mode and system control. Connecting two Net-2000™-VCU units together can be done by entering the IP address (or hostname) of the other Net-2000™-VCU unit and selecting the desired voice interface.

3.1 Net-2000™-VCU Control Via Web Interface

The Net-2000™-VCU can be controlled remotely by accessing the unit's built-in web server using a PC's web browser as the graphical user interface. To connect to the Net-2000™-VCU web server home page, first open up the web browser software on a PC and type the IP address (or hostname if the LAN has a name server) of the VCU you want to control in the URL address bar. The VCU web server will respond with the VCU Page as shown in Figure 6 Net-2000™-VCU Page.

The Net-2000™-VCU's built-in web server provides I/O configuration, system control, information about the operational mode and network settings.

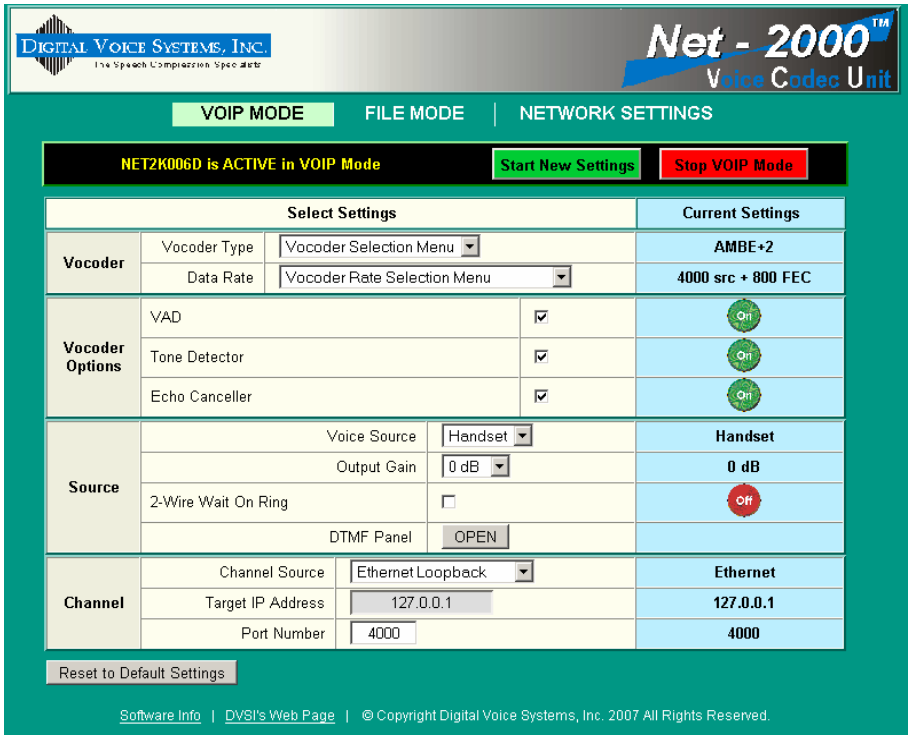

Figure 6 Net-2000™-VCU Page

(values will vary for Net-2000™-VCU version)

The page is designed to give the operator a operator control and summary of all the settings and parameters of the Net-2000™-VCU. The page shows the current status of the Net-2000™-VCU, information on what the data rate and a navigation menu for switching to pages to change system settings. The Vocoder Options table gives the operator control over features (such as VAD and Echo Cancellor, etc.) that are available to the specific vocoder implemented. The Voice Source Selection table provides information from the communications channel and configuration of the vocoder output gain. The operator can control the running of the unit using the Start / Stop button at the top of the page.

3.2 Navigation Menu

Located across the top under the logo header the navigation menu provides the link to the three main pages used for setup and control of the Net-2000™-VCU. This menu is visible and assessable from any of the pages. The menu item is highlighted when the page is displayed.

Figure 7 Navigation Menu

3.2.1 VOIP Mode

Provides selection of I/O, vocoder rate and options, and control of DTMF selection pop up window. The VOIP Mode window also provides a view of the current setting and system condition.

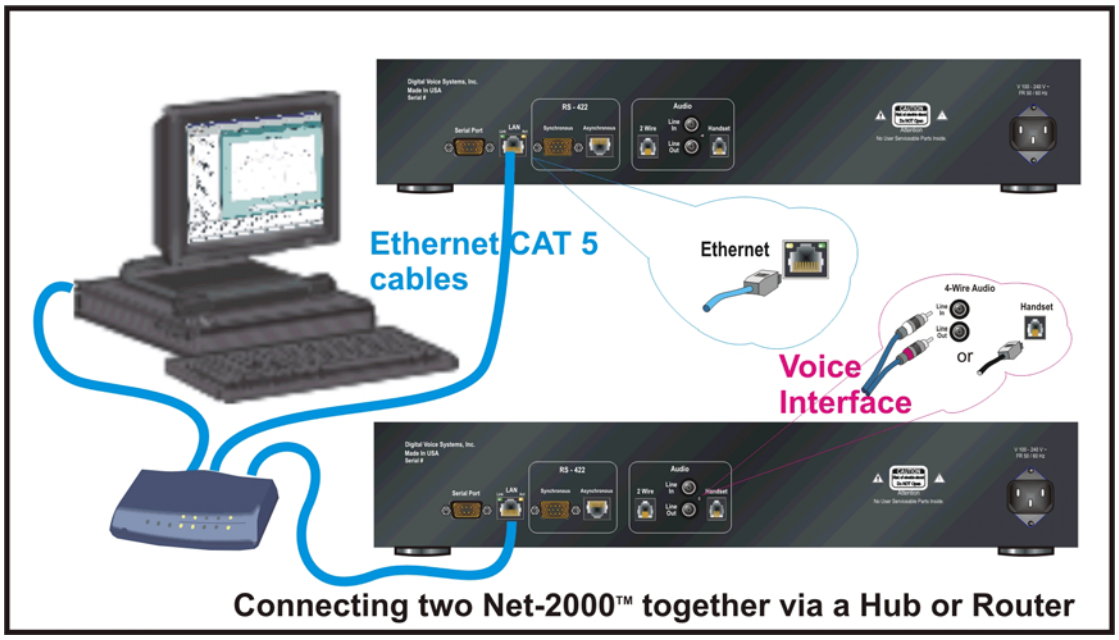

Figure 8 Example Setup for VOIP Mode

3.2.2 File Mode

Put the Net-2000™-VCU into a ready mode to accept files via Ethernet from a PC. Also allows start and stop of process.

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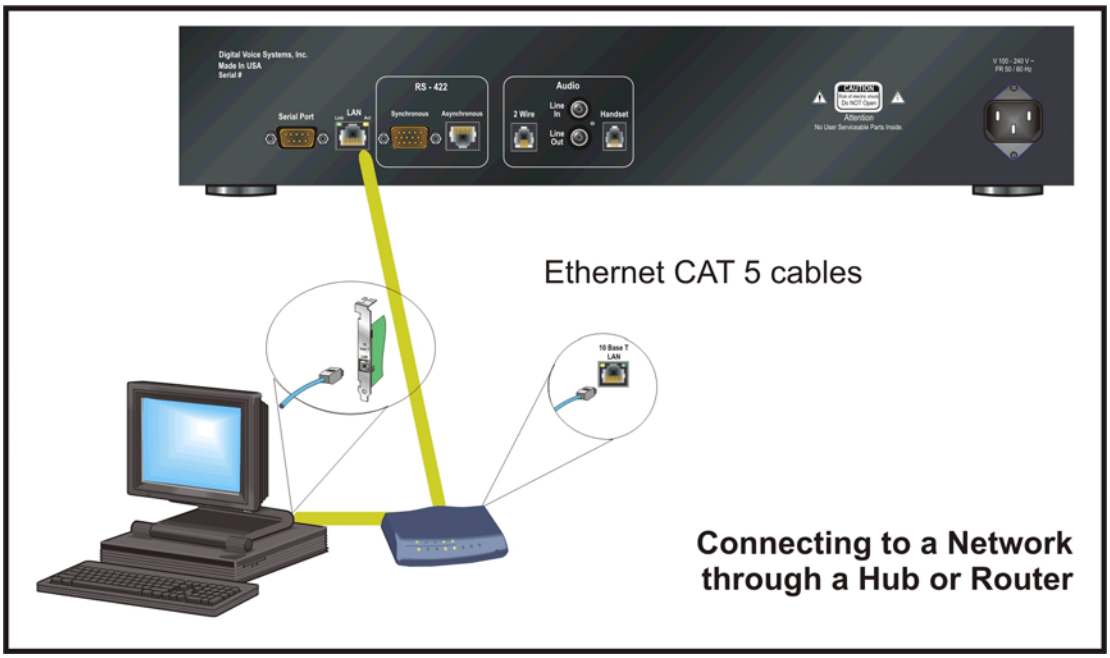

Figure 9 Example Setup for File Mode

3.2.3 Network Settings Page

Selecting the System Settings from the navigation menu will display a window with the current network information of the Net-2000™-VCU. The user can set the Net-2000™-VCU to either obtain the network settings automatically from a DHCP server (if available) or the user can manually enter the required settings.

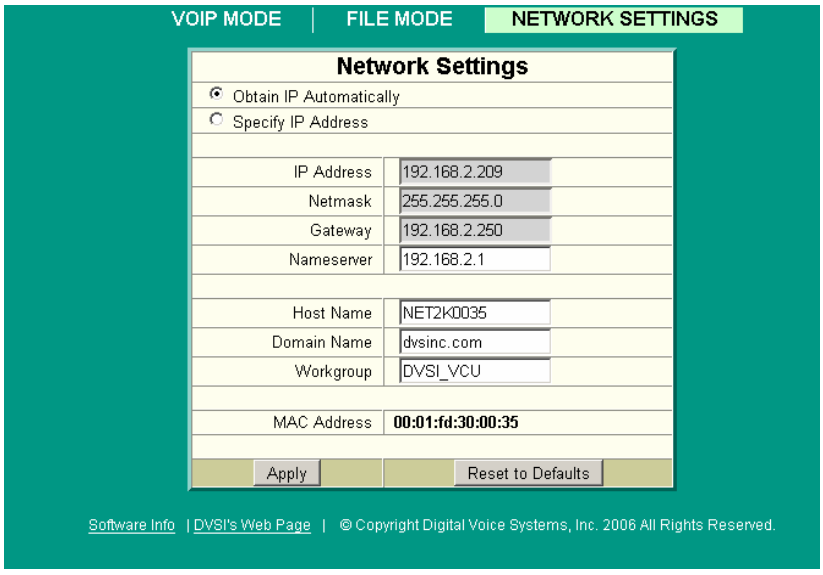

Figure 10 Net-2000™-VCU Network Settings Window

3.2.3.1 Obtain IP Automatically Radio Button

When selected the Net-2000™-VCU will get its network settings from the DHCP server on the LAN.

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3.2.3.2 Specify IP Address Radio Button

When selected the Net-2000™-VCU allows the operator to manually set up the Ethernet network parameters. After new values have been entered, select the APPLY Button to reboot the Net-2000™-VCU and have the new network settings take effect.

3.2.3.3 Reset to Defaults Button

The Network Settings "Reset to Default" button resets the Net-2000™-VCU network setting value to obtain IP setting from a DHCP server.

Apply Button
The Apply button applies the settings that are entered in the network settings screen. When selected the Net-2000™-VCU automatically stops and reboots to implement the new settings that were entered.

3.3 Status Control Bar

Located just under the navigation menu is the status indication. This informs the operator of the state of the Net-2000™-VCU. The status screen displays the host name of the Net-2000™-VCU, what mode the unit is in and the current running condition. Upon power up the Net-2000™-VCU loads the default settings and the unit is idle. Click the Start button to begin running the VCU with the default settings. Click the Stop button to put the Net-2000™-VCU back into the idle mode. Changes to the settings can be made while the unit is active. However, the new settings will not take affect until the Start button is clicked.

Note: The "Start New Settings" button will automatically stop and restart the Net-2000™-VCU. It is not necessary to click on the "Stop" button and then click the Start button to restart the Net-2000™-VCU with a new setting.

Figure 11 Net-2000™ VCU Status

3.3.1 Net-2000™- is Idle

The Net-2000™-VCU is idle when the unit is stopped. In this condition the unit is ready to process data through the encoder or decoder when the START button is selected.

3.3.2 Net-2000™- is Active

When the Net-2000™-VCU is active the unit is The unit will return to idle when the STOP button is selected.

3.3.3 Start and Stop Buttons

The Start VOIP Mode button is used to apply all the selected settings on the VOIP page and begin communication between two Net-2000™-VCUs. The Net-2000™-VCU will remain active in VOIP mode until either the Stop VOIP mode button is selected or the Start File Mode Button on the File Mode page is selected.

When the Start File Mode Button is selected the Net-2000™-VCU is able to process data via the Ethernet interface. The Net-2000™-VCU will remain active in file mode until either the Stop file mode button is selected or the Start VOIP Mode Button on the VOIP page is selected.

3.4 Reset to Defaults Button

A Reset to defaults button is provided to set the I/O and vocoder conditions to the factory default state. Selecting this reset buttons set the Vocoder Setting Page to the settings that a set on start-up. The Default vocoder values vary depending on the vocoder implementation.

NOTE: At power-up the VCU automatically starts up with the default settings. You do not need to use the web interface unless you want to change these settings.

3.5 Version Identification

Selecting the Software Info from the bottom of any page will display a window with the current software version of the Net-2000™-VCU and the version of the implemented vocoder. There are no user definable settings on this page.

3.6 Hyperlink to DVSI Web Page

Selecting DVSI's Web Page from any of the pages will go out of the Local Area Network to the Internet to a DVSI web page dedicated to Net-2000™ information as well as available manual download.

3.7 VCU Control via Serial Interface

The serial port located on the back of the Net-2000™-VCU unit provides the same control functions as the web interface. The interface itself consists of a simple command/response ASCII text protocol. To access the interface use a terminal or terminal emulator on a personal computer to type in commands.

All commands are ASCII character strings terminated by a newline character (ASCII 0x0A). The maximum size allowed for a command is 512 characters. Commands are case-sensitive. Command arguments are separated by white space. With the serial cable connected and the terminal running type a few carriage returns at the keyboard. The Net-2000™-VCU responds with the console prompt as shown below:

adsh>

Commands to the Net-2000™-VCU can be issued after receiving the prompt. Each time a command is issued to the Net-2000™-VCU it will respond with a string indicating the command was accepted as “OK” or an error message. After another prompt is ready to receive a new command. Any newline-terminated string reported by the Net-2000™-VCU between the time a command is issued and a new command prompt is received indicates an error was encountered executing the command.

Commands consist of a command word, zero or more arguments, and a newline (which marks the end of the command). Commands for the serial port interface are listed in the following subsections.

When issuing commands at the "adsh>" prompt the NET-2000™ VCU will respond with "<cmd> OK" (where <cmd> is the command issued) or an error message if the command fails.

3.7.1.1 VOIP mode command

The VOIP commands start the Net-2000™-VCU to VOIP mode.

```
adsh> dut voip <args>
```

where args are

arg format	arg name	arg values
-v [h,l,2,2r]	voice source	h=handset, l=4-wire, 2=2-wire, 2r=2-wire wait on ring
-c [e,a,s]	channel source	e=ethernet, a=RS-422 Asynchronous, s= RS-422 Synchronous
-o [gain]	codec output gain	0,-3,-6 dB
-p [port]	port number	for channel source == Ethernet
-d [config]	configuration data	for VAD, Tone Detection, Noise Suppression, Echo canceller Auto Gain Control (AGC) and High Pitch Detection (in order) depending on the vocoder implementation to turn a configuration on use '1' to turn it off use '0'
For example: "-d 1 0 0 1 0 0" turns vad ON, echo canceller ON only		
-r [vocoder]	vocoder and FEC	vocoder type is "AMBE+2", to specify FEC on or off pass in ",<rate_index>"
For example: "-r AMBE+2t,01" specifies -1 vocoder with no FEC		
[ip_addr]	the IP address to send data to	required only if the channel interface is Ethernet

3.7.1.2 VOIP Mode Command Example

```
adsh> dut voip -v l -c e -r AMBE+2,00 192.168.24.173
```

In this example the Net-2000™-VCU starts VOIP Mode using the 4-wire interface for voice and Ethernet for the channel using the -1 vocoder with FEC enabled. It communicates with the device at ethernet address 192.168.24.173 with the default UDP port (4000).

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3.7.1.3 FILE mode command:

The File mode command set the Net-2000™-VCU to work in file mode.

```
adsh> dut file <args>
```

where args are

arg format	arg name	arg values
-p [port]	port number	only for channel source == ethernet
-d [config]	configuration data	for VAD, Tone Detection, Noise Suppression, Echo canceller Auto Gain Control (AGC) and High Pitch Detection (in order) depending on the vocoder implementation to turn a configuration on use '1' to turn it off use '0'
For example: "-d 1 0 0 1 0 0" turns vad ON, echo canceller ON only		
-r [vocoder]	vocoder	vocoder type ONLY (no need to specify FEC) vocoder type is "AMBE+2",

NOTE: FILE mode implies that both the voice and channel interfaces are Ethernet. Since the rate information is always in the packet, there is no need to specify the rate index.

3.7.1.4 Stop Command

The Stop command works for either mode and sets the Net-2000™-VCU to IDLE

```
adsh> dut stop
```

Change Vocoder Configuration:

```
adsh> dut config [config]
```

[config] are the same 1 or 0 values used in the "-d [config]" arg for voip or file mode

3.7.1.5 Send Tones Command

```
adsh> dut tone [-te or-td] [tone_args]
```

where args are

"-te" or "-td".	[enc_or_dec]	Either "-te" or "-td". "-te" means override the speech input and have the encoder send the tones in-band to the other net2k "-td" means override the input channel data and have the decoder generate the tones locally.
[tone_args]		an ascii string of digits and the upper-case letters [A-F] representing the DTMF tone to generate

3.7.1.6 Stop Command

To use the stop command at the adsh> prompt type

```
dut stop
```

The Net-2000™-VCU responds with Stop OK and packets information

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4 VOIP Mode

When the Start VOIP button is selected the unit is active in VOIP mode and ready to communicate with another Net-2000™ VCU via the Ethernet interface. VOIP mode can also be used for Loopback communications where it sends data to itself over the internal loopback Ethernet address of 127.0.0.1

4.1 Net-2000™-VCU VOIP Mode Settings

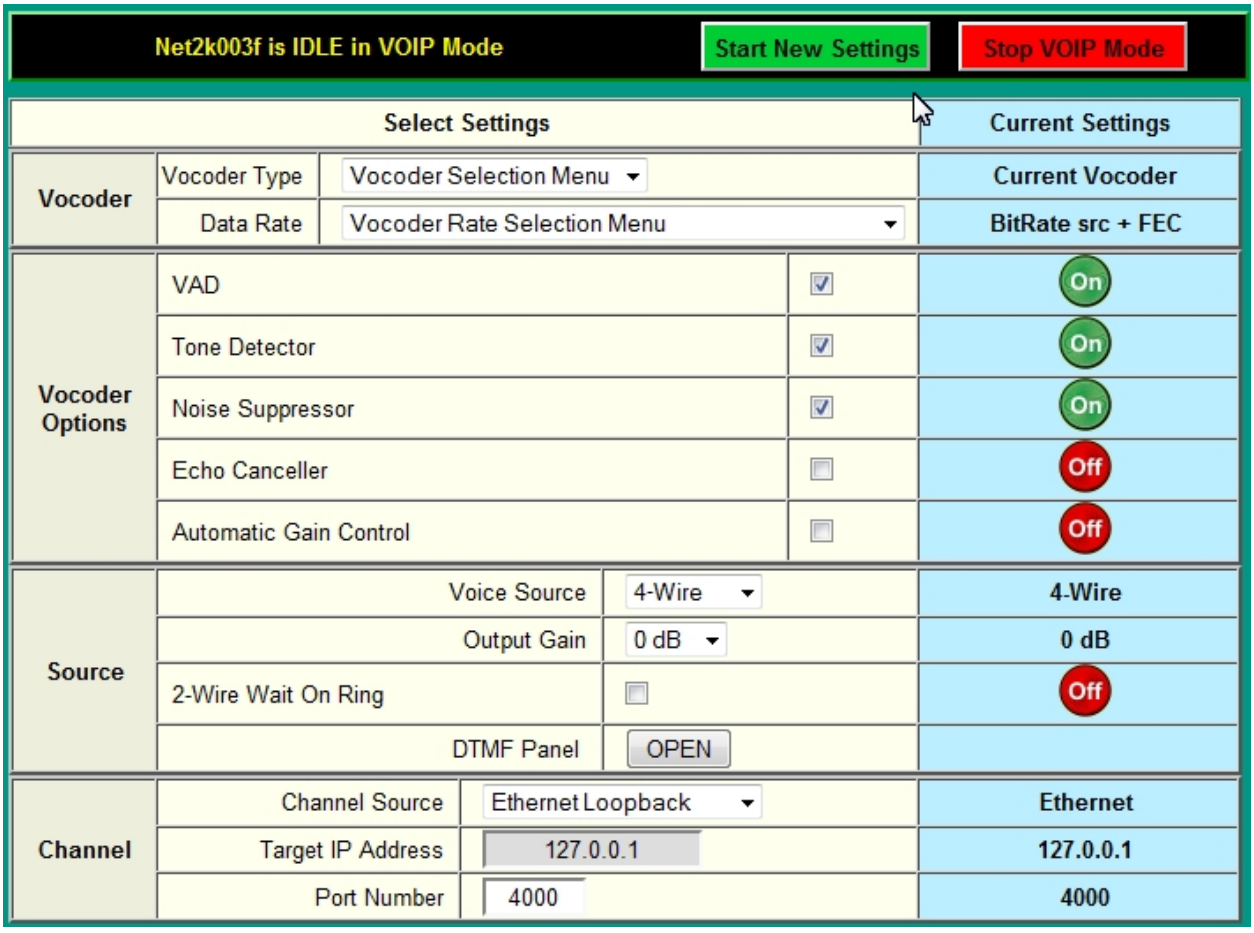

Figure 12 Net-2000™- VOIP Settings

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4.2 Vocoder Selection (Version Dependant)

The Net-2000™ VCU is available in a variety of vocoder configurations. Depending on the version purchased the unit may contain one or two of the following vocoders. All versions of the Net-2000™ VCU include A-law and U-Law.

Vocoders
AMBE®
AMBE+™
AMBE+2™
APCO Standard
APCO Enhanced
GMR-1 Vocoder
GMR-2 Vocoder
BGAN Vocoder
GMR-2+ Vocoder
A-Law
U-Law

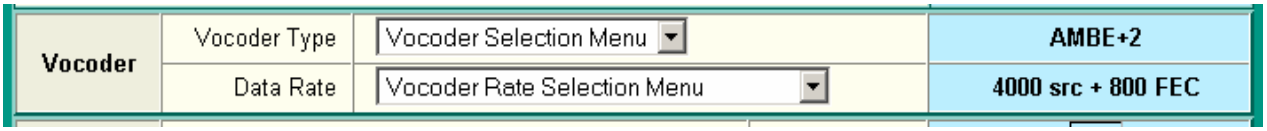

Figure 13 Vocoder Type and Rate Selection

4.2.1 Forward Error Correction (FEC)

FEC is built into the following version of the Net-2000™ VCU.

Vocoder
AMBE®
AMBE+™
AMBE+2™
APCO Standard
APCO Enhanced
GMR-1 Vocoder
GMR-2+ Vocoder

The vocoder can be selected with or without FEC to allow for various testing conditions. This is a feature that is ideal for mobile communication applications that experience degraded channel conditions and/or significant bit errors.

4.3 APCO Vocoder Version – APCO Standard and APCO Enhanced

The Vocoder Type selection window allows the operator to select between the APCO Standard and APCO Enhanced Vocoders. Only one vocoder can be selected at a time. After switching from one vocoder to the other it is necessary to select the start button in order to initiate the change.

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APCO Standard Vocoder Mode
The Full-Rate mode is compatible with the current APCO P25 standard. The P25 standard vocoder has a total data bit rate of 7200 bps. Of these bits 4400 bps is voice data and 2800 bps is Forward Error Correction (FEC). The vocoder can be selected with or without FEC.

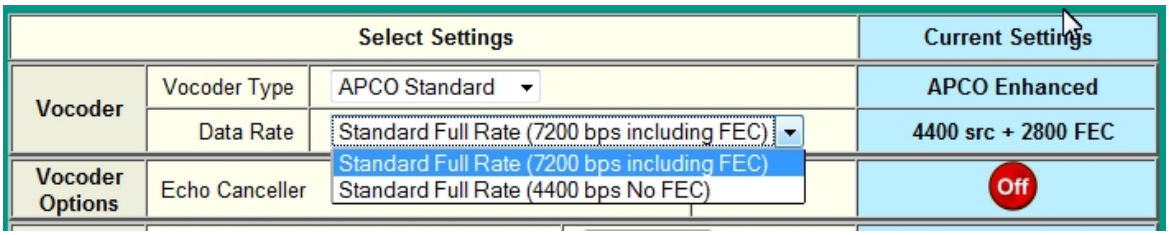

Figure 14 APCO Standard Vocoder Selection

The APCO Enhanced Vocoder is DVSI's new vocoder technology. The APCO Enhanced vocoder in the Net-2000™- P25 VCU offers the flexibility of data rate, FEC and Bit stealing selection. of 3600 bps. This new vocoder is designed to be particularly robust and perform exceptionally well even under the presence of bit errors and acoustic background noise conditions.

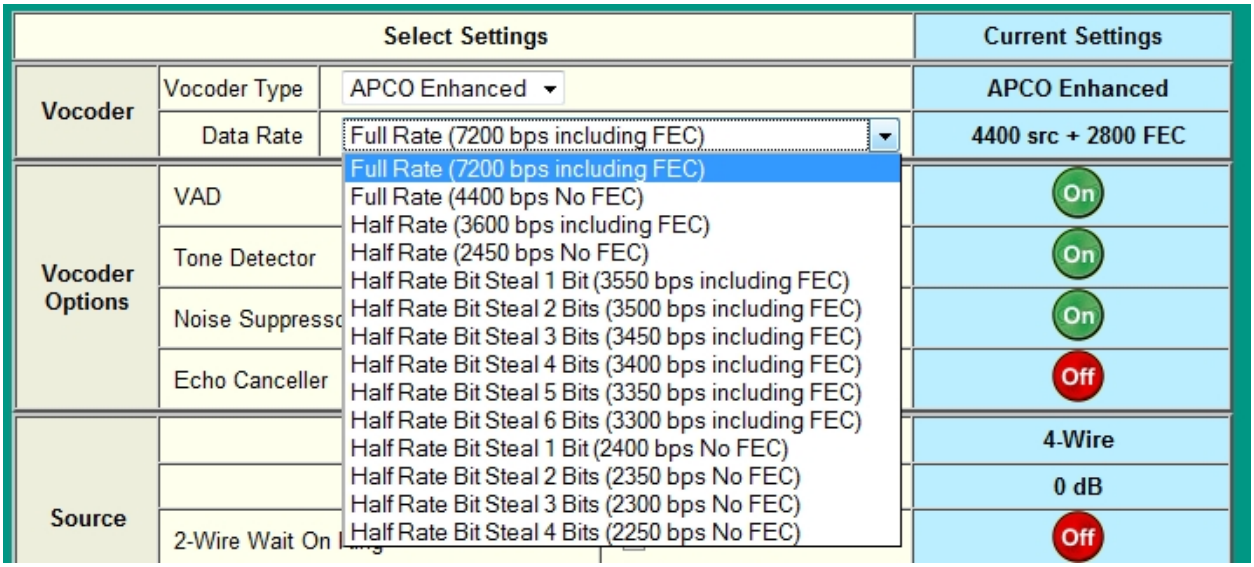
Select Settings
Current Settings
Vocoder
Vocoder Type
APCO Enhanced
APCO Enhanced
Data Rate
Full Rate (7200 bps including FEC)
4400 src + 2800 FEC
Full Rate (7200 bps including FEC)
Full Rate (4400 bps No FEC)
Half Rate (3600 bps including FEC)
Half Rate (2450 bps No FEC)
Half Rate Bit Steal 1 Bit (3550 bps including FEC)
Half Rate Bit Steal 2 Bits (3500 bps including FEC)
Half Rate Bit Steal 3 Bits (3450 bps including FEC)
Half Rate Bit Steal 4 Bits (3400 bps including FEC)
Half Rate Bit Steal 5 Bits (3350 bps including FEC)
Half Rate Bit Steal 6 Bits (3300 bps including FEC)
Half Rate Bit Steal 1 Bit (2400 bps No FEC)
Half Rate Bit Steal 2 Bits (2350 bps No FEC)
Half Rate Bit Steal 3 Bits (2300 bps No FEC)
Half Rate Bit Steal 4 Bits (2250 bps No FEC)
Vocoder Options
VAD
On
Tone Detector
On
Noise Suppressc
On
Echo Canceller
Off
Source
4-Wire
0 dB
Off

Figure 15 APCO Enhanced Vocoder Selection

4.3.1 APCO Enhanced Vocoder Bit Stealing

The APCO Enhanced vocoder offer the ability to steal up to six bits from the vocoder. This mode can be used to transmit user data in-band.

4.3.2 APCO Enhanced Vocoder Additional Features

As part of Half-Rate vocoder mode the Net-2000™ VCU offers the ability to decode up to 8 bits of Soft Decision Forward Error Correction. This feature is ideal for testing and evaluating degraded channel conditions and/or significant bit errors.

In addition to the enhanced FEC capability the Net-2000™ VCU Half-Rate vocoder provides voice activity detection and DTMF Knox Tone detection and regeneration. See Section 4 Protocol for more information.

4.4 AMBE® / AMBE+™ Vocoders Version

The AMBE® mode is compatible with DVSI's AMBE-1000™, AMBE-2000™ and AMBE-2020™ Vocoder Chips. DVSI's proprietary AMBE® Voice Compression Technology delivers excellent voice quality even at low data rates. Proven to be a superior alternative to linear predictive model vocoders, the AMBE® Voice Compression Technology has been chosen as the standard for several major satellite and mobile radio communications systems. The Net-2000™ VCU supports AMBE® Vocoder bit rates from 2000 to 9600 bps. The rates available are the combination of the speech data and the Forward Error Correction (FEC).

Independent test results have shows DVSI's AMBE+™ Vocoder running at 4.8 kbps and 4.0 kbps outperforms both the ITU G.726A vocoder at 32 kbps and the ITU G.729 vocoder at 8 kbps. This voice coder builds upon the strengths of DVSI's previous IMBE™ and AMBE® Technology to provide toll quality speech with unsurpassed robustness to both acoustic noise and channel errors. The AMBE+™ Vocoder provides a 2-8 times reduction in bit rate while delivering toll-quality performance with maximizing bandwidth efficiency.

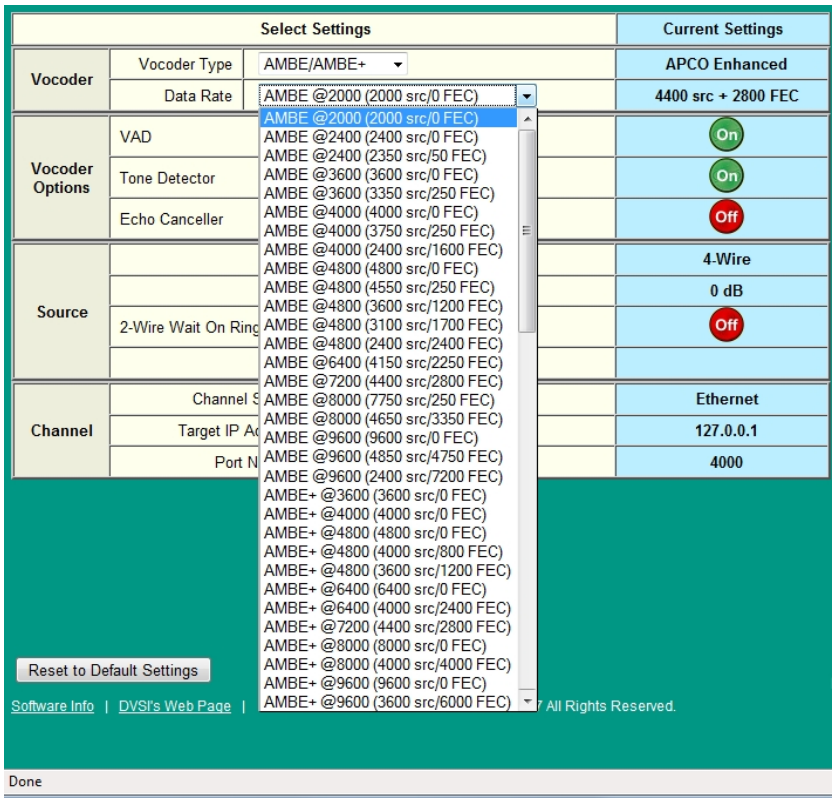

Figure 16 AMBE® / AMBE+™ Vocoder Type and Rate Selection

Vocoder Type and rate/FEC selection is done from the VOIP Mode window. To set the Net-2000™ VCU vocoder, first select the vocoder mode (AMBE® / AMBE+™ or AMBE+2™), then select the Rate / FEC using the Bit Rate drop down menu. The default vocoder is set to AMBE+2™ @ 4000 bps with 0 bps FEC.

4.5 AMBE+2™ Vocoder Version

The AMBE+2™ Vocoder is DVSI's newest low data rate vocoder technology. The Net-2000™ VCU incorporates the AMBE+2™ Vocoder at 4.0 kbps with no FEC. It has been shown to outperform DVSI's previously industry-leading AMBE+™ Vocoder and AMBE™ vocoder technologies. It is designed to be particularly robust and perform exceptionally well even under bit errors and acoustic background noise conditions.

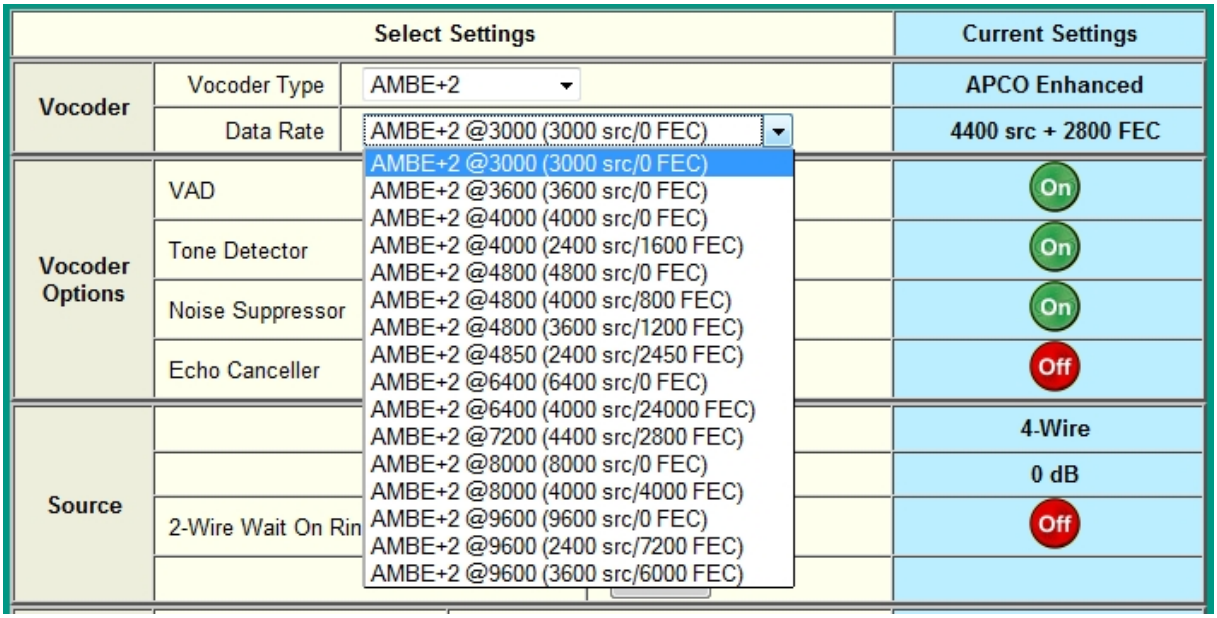

Table 5 AMBE+2™ Vocoder Data Rate Selection

4.6 Vocoder Selection (GMR-1 or GMR-2 Version)

Vocoder Type and rate/FEC selection is done from the VOIP Mode window. The user has the ability to run the GMR-1 or GMR-2 (depending on the Net-2000 version) vocoder with or without FEC using the Data Rate drop down menu. The default rate for the GMR-1 vocoder is 5200 bps (4000 bps speech source with 1200 bps FEC). The only rate for the GMR-2 vocoder is 3600 bps (3600 bps speech source with 0 bps FEC).

4.6.1 GMR-1 Vocoder Selection

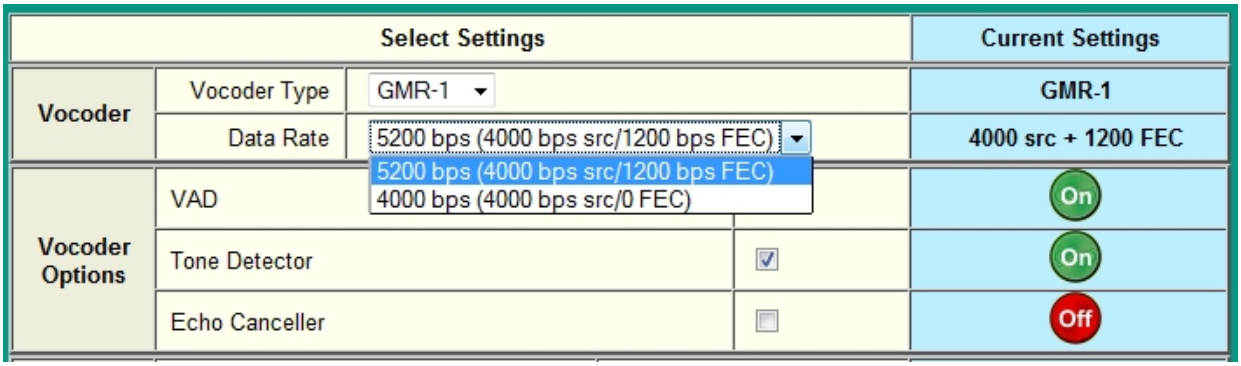

Figure 17 GMR-1 Vocoder Selection

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4.6.2 GMR-2 Vocoder Selection

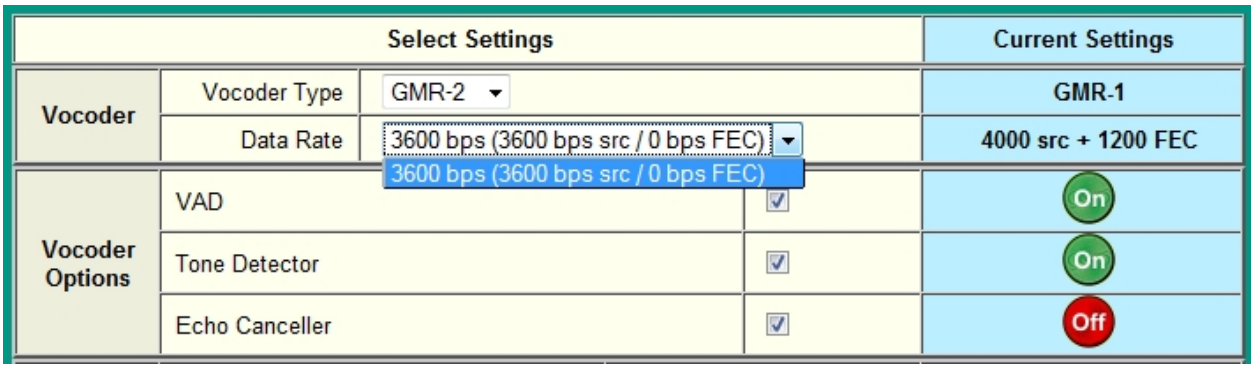

Figure 18 GMR-2 Vocoder Selection

4.7 BGAN Vocoder Selection

The VCU contains an implementation of Inmarsat's BGAN 4 kbps vocoder. Vocoder Type selection is done from the VOIP Mode Vocoder window. The only BGAN vocoder data rate option user has the ability to run is 4000 bps with no FEC. This is the default and only selection in the drop down menu.

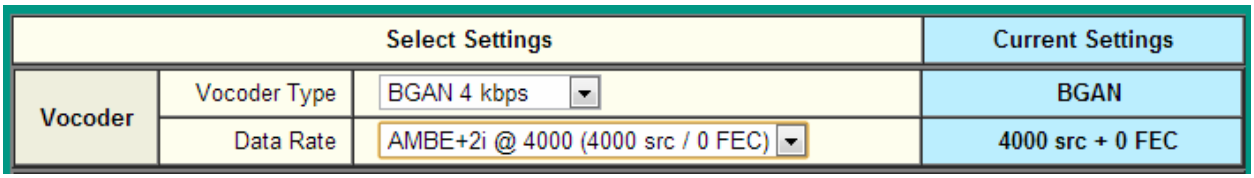

Figure 19 BGAN Vocoder Selection

4.8 GMR-2+ Vocoder Selection

To run the GMR-2+ vocoder , select it from the Vocoder Type drop down. The user has the ability to run GMR-2+ vocoder with or without FEC using the Data Rate drop down menu. The default rate for the GMR-2+ vocoder is 6000 bps (2450 bps speech source with 3550 bps FEC). Other rates available for the GMR-2+ vocoder are as follows: 2450 bps speech with 0 bps FEC; Bit Steal one bit - 2450 bps speech source with 3550 bps FEC; Bit Steal one bit - 2450 bps speech with 0 bps FEC.

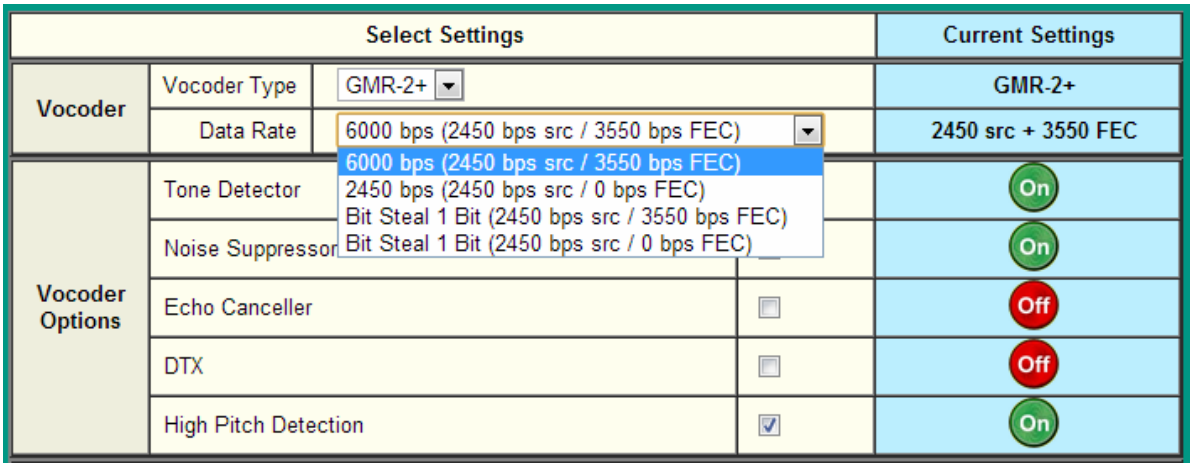

Figure 20 GMR-2+ Vocoder Selection

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4.8.1 Rate "Bit Steal 1 Bit"

The two "Bit Steal 1 Bit" rates allow for customized data signaling. When running in one of these rates the value of the least significant bit of the data bits has no effect on the vocoder. The "Bit Steal one bit - 2450 bps speech source with 3550 bps FEC" rate has 72 bits of data, so the value of the LSB (bit 71 of the channel data bits) does not influence the vocoder. The "Bit Steal one bit - 2450 bps speech with 0 bps FEC" rate has 49 bits of data, so the value of LSB (bit 48 of the channel data bits) has no effect on the vocoder. Since the vocoder does not care about the value of this data bit, users can steal this bit for customized use.

4.9 Vocoder Options Configuration

To fine tune the capability of either vocoder mode the NET-2000™-VCU provides VAD, Echo cancellation Tone Detector and Automatic Gain Control options. The availability of these extended features depends on the vocoder selection. To turn ON an option use the home page navigation menu to get to the VOIP Page and click on the check box for the desired vocoder option. Then click on the Start button to enable the new setting selection.

Vocoder Options	Tone Detector	☑	On
	Noise Suppressor	☑	On
	Echo Canceller	☐	Off
	DTX	☐	Off
	Automatic Gain Control	☐	Off
	High Pitch Detection	☑	On

Figure 21 Vocoder Options

4.9.1 Voice Activation Detection (VAD)

The Voice Activation Detection (VAD) algorithm along with the Comfort Noise Insertion (CNI) feature of the NET-2000™-VCU is a useful function for systems trying to save in system bandwidth or to reduce transmit power during times of conversational silence.

With the VAD functions enabled, periods of speech silence will be recognized by the encoder. Instead of compressing the silence as speech the encoder outputs a silence frame (in-band). This silence frame contains information regarding the level of background noise, which allows the corresponding decoder to synthesize a "Comfort Noise" signal at the other end. The comfort noise is intended to give the listener the feeling that the call is still connected, as opposed to producing absolute silence, which can give the impression that, the call has been "dropped".

The silence threshold value is -25 dBm0 in the VAD algorithm. Each frame that exceeds this level will be classified as voice. If the frame level is less than -25 dBm0 the voice/silence decision will be determined based upon various adaptive thresholds.

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VAD is available with the following vocoders:

Vocoder
AMBE®
AMBE+™
AMBE+2™
APCO Enhanced
GMR-1
GMR-2
BGAN Vocoder (Always ON)
GMR-2+ Vocoder (Always ON)

Note: The VAD is always enabled when BGAN or GMR-2+ is selected as the vocoder type.

4.9.2 Tone Detector

The Tone detector can be turned on or off is selected using the checkbox. When the Tone detector in enabled the Net-2000™ VCU is able to send and receive North American DTMF tones.
Tone Detection is available with the following vocoders:

Vocoder
AMBE® (Always ON)
AMBE+™ (Always ON)
AMBE+2™
APCO Enhanced
GMR-1
GMR-2
BGAN Vocoder
GMR-2+ Vocoder

Note: The Tone detector is always enabled when AMBE®/AMBE+™ is selected as the vocoder type.

4.9.3 Noise Suppressor

The Noise suppressor feature of the Net-2000™ VCU provides clear voice in environments with background noise. This feature work only when one of the vocoders indicated below is selected as the vocoder type. To enable the feature select the check box in the Configuration table on the VOIP page. The noise suppressor can be switched off by unchecking the check-box. When the noise suppressor is started it may take up to a few seconds to converge allowing for it do begin fully working.

Noise Suppression is available with the following vocoders:

Vocoder
AMBE+2™
APCO Enhanced
BGAN Vocoder
GMR-2+ Vocoder

4.9.4 Echo Canceller (Echo)

The AMBE® software on the NET-2000™-VCU employs an adaptive echo cancellation algorithm to cancel echoes of the decoder output present at the encoder input. This provides a 16-millisecond echo canceller that is suitable for canceling the linear portion of the local echo caused by a 2-to-4 wire hybrid and can achieve echo cancellation of approximately 30dB or more. The Echo canceller is only really useful when connected via the 2-wire interface.

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Echo Canceller is available with the following vocoders:

Vocoder
AMBE®
AMBE+™
AMBE+2™
APCO Enhanced
GMR-1
GMR-2
BGAN Vocoder
GMR-2+ Vocoder

4.9.5 DTX (BGAN and GMR-2+ Vocoders Only)

The Discontinuous Transmission (DTx) feature is used in conjuction with VAD. It can be used to reduce transmit power during times of conversational silence. When DTx is checked (DTX_ENABLE=1), the encoder will output a silence frame (in-band) whenever the speech data is determined to be background noise or silence.

This silence frame contains information regarding the level of background noise, which allows the corresponding Net-2000's decoder to synthesize a "Comfort Noise" signal. The comfort noise is intended to give the listener the feeling that they are still connected, as opposed to producing absolute silence, which can give the impression that, the connection has been "dropped".

To ensure the smoothest audible transitions between synthesized speech and synthesized silence, DVSI recommends the user to send a silence frame with background noise level parameters to the decoder approximately every 500-1000 milliseconds. The encoder and decoder expects that most silence frames will be discarded and that only an occasional silence frame (approximately one per second) may be transmitted to update the CNI state at the decoder.

When DTX is not checked (DTX_ENABLE=0), the encoder does not output special silence frames when silence is detected.

DTx is available with the following vocoders:

Vocoder
BGAN Vocoder
GMR-2+ Vocoder

4.9.6 Automatic Gain Control (APCO Enhanced Vocoder Only)

The Automatic Gain Control (AGC) attempts to amplify or attenuate the incoming signal to maintain a relatively constant voice level. The applied gain is limited to [+20,-10] dB. Automatic Gain Control is available with the following vocoders:

Automatic Gain Control detection is available with the following vocoder:

Vocoder
APCO Enhanced

4.9.7 High Pitch Detection Feature (GMR-2+ Vocoder Only)

When checked (enabled) High Pitch Detection (HPD) increases the pitch range of the vocoder in order to accommodate voices with an especially high pitch voice. The vast majority of speakers do not exceed the vocoder's typical pitch limits. In very rare cases when HPD is required it may be enabled.

With the HPD not checked (not enabled) the vocoder creates a period of constant pitch when it receives any pitch fluctuations above the maximum pitch limit. During this time the decoded voice may sound somewhat different but is still understandable and the intelligibility is reasonably preserved.

The High Pitch detection feature is available with the following vocoder:

Vocoder
GMR-2+ Vocoder

4.10 Source Selection

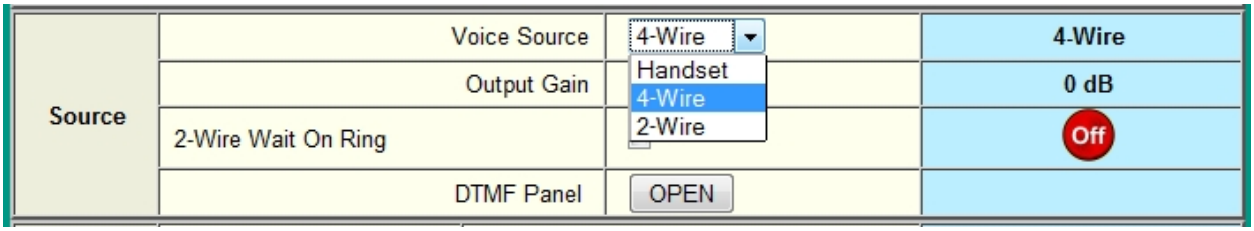

Figure 22 Voice Source Selection

4.10.1 Voice Source

The Voice Source menu provides the user the choice to select which input source will be used on the Net-2000™-VCU. The default source is set to 4-Wire. Only one source may be selected at a time. After switching from one voice source to another it is necessary to select the start button in order to initiate the change.

4.10.1.1 Handset

When the Handset voice source interface is selected, the Net-2000™-VCU expects the analog voice signal input and output on the RJ11 jack (Item 8 in Figure 1 Net-2000™-VCU Rear Panel). The output will also be on the output RCA jack (Item 6 Figure 1 Net-2000™-VCU Rear Panel). The Net-2000™-VCU outputs the audio to both the 4-Wire and Handset output regardless of which voice source is selected.

4.10.1.2 4-Wire

When the 4-Wire voice source interface is selected, the Net-2000™-VCU expects the analog voice signal input on the RCA jack (Item 7 in Figure 1 Net-2000™-VCU Rear Panel). The unit outputs the analog signal on the output RCA jack (Item 6 Figure 1 Net-2000™-VCU Rear Panel). The Net-2000™-VCU outputs the audio to both the 4-Wire and Handset output regardless of which voice source is selected.

4.10.1.3 2-Wire

Before selecting the 2-Wire voice source the Net-2000™-VCU expects to be connected to a North American POTS line. A industry standard telephone cord can be used to connect the wall jack to the RJ11 jack (Item 5 in Figure 1 Net-2000™-VCU Rear Panel). When the 2-Wire voice source interface is selected, the Net-2000™-VCU automatically “picks-up” (opens) the line. When the voice source set to 2-wire the incoming analog signal from the POTS line will be encoded and then output to the selected channel interface (RS-422 or Ethernet). If the Ethernet loopback channel is selected then the encoded speech will be decoded and sent out through the POTS line. The Net-2000™-VCU 4-Wire and Handset outputs are not active. The POTS line can be hung-up (released) by selecting the Stop VOIP button.

4.10.2 Output Gain

The output gain setting for the voice codec can be set by the user, however, the default values should be sufficient for most applications. The Output gain can be set to -3dB or -6 dB.

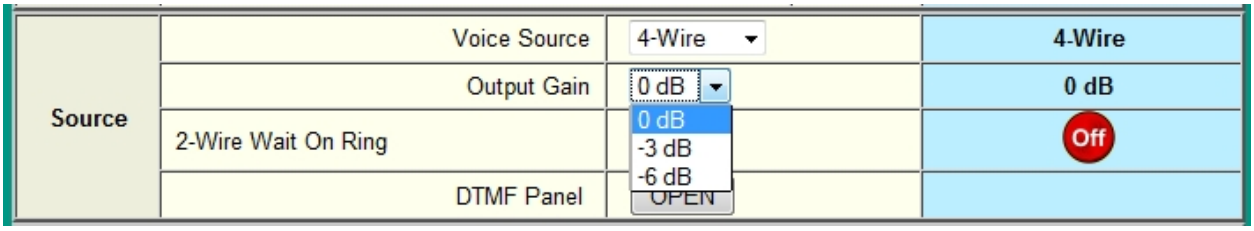

Figure 23 Output Gain Selection

4.10.3 2-Wire Wait on Ring

The 2-Wire wait on ring feature allows the Net-2000™-VCU to be ready to answer an incoming call from a standard POTS line. When selected the Net-2000™-VCU will not automatically open the POTS line when the 2-Wire voice source is selected. This provides the benefit of freeing up the phone line when the Net-2000™-VCU is not active.

4.10.4 DTMF Panel

The NET-2000™-VCU is capable of detecting, transmitting, and synthesizing DTMF tones. DTMF features are only enabled in VOIP Mode with vocoders that support DTMF Tones. Selecting the "OPEN" button next to the DTMF Panel on the main navigation menu brings the operator to the Status page and opens the DTMF pop-up window (see Figure 24 DTMF Key Pad).

The DTMF pop-up window allows the operator to send DTMF tones across the channel. The operator can enter the tones by selecting the digits in the pop-up window or by selecting the DTMF digit window and entering the numbers using the keyboard. The operator can select how the tone should be generated and then can select send to send the information the Net-2000™-VCU.
The frequencies for the DTMF tones are shown in Table 6 DTMF Data

Digit	DTMF Frequency 1 (Hz)	DTMF Frequency 2 (Hz)
0	1336	941
1	1209	697
2	1336	697
3	1477	697
4	1209	770
5	1336	770
6	1477	770
7	1209	852
8	1336	852
9	1477	852
A	1633	697
B	1633	770
C	1633	852
D	1633	941
*	1209	941
#	1477	941

Table 6 DTMF Data

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*Note: Dial, ring, and busy tones are standard North American call progress tones.

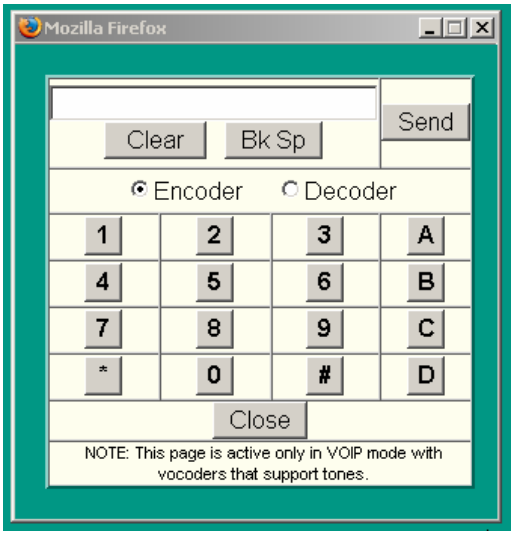

Figure 24 DTMF Key Pad

4.10.4.1 Send Button

The Send button sends the digits entered in the DTMF digit window out to the select device (encoder or decoder)

4.10.4.2 Clear Button

The Clear button allows the operator to delete all the digits entered in the DTMF digit window.

4.10.4.3 BK SP Button

The BK SP button allows the operator to delete the last digit entry from the DTMF digit window.
Encoder Radio Button
When the Send button is selected and the Encoder radio button is active then the digits in the DTMF window are sent from the encoder across the channel. A the other side of the channel the information is decoded. The encoder and decoder radio button can not be active at the same time. The encoder passes the DTMF data in-band (within the regular voice data bits) so that normal DTMF tones pass seamlessly from the encoder to the decoder. The decoder synthesizes a DTMF tone in response to reception of an in-band DTMF tone data in the frame.

4.10.4.4 Decoder Radio Button

When the send button is selected and the Decoder radio button is active then the Net-2000™-VCU sends tone directly to the local decoder to output the digits as entered in the DTMF digit window. The decoder and encoder radio button can not be active at the same time.
Close
Selecting the Close button closes the DTMF pop-up window.

4.11 Channel Settings

The Net-2000 can be configures to encode / decode speech from one of three communications channel sources. The default channel is Ethernet loopback. Only one communication mode may be selected at a time. After switching from one communication mode to another it is necessary to select the start button in order to initiate the change.

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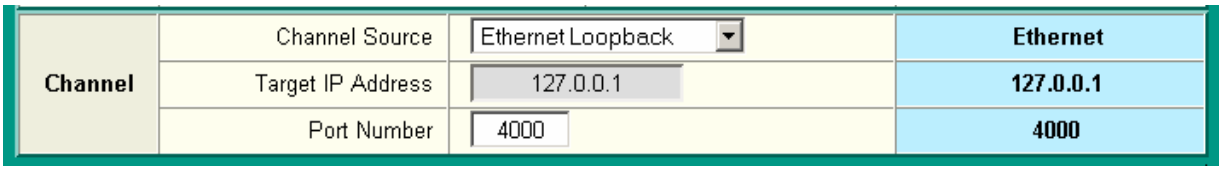

Figure 25 Channel Source

4.11.1 Channel Source Selection

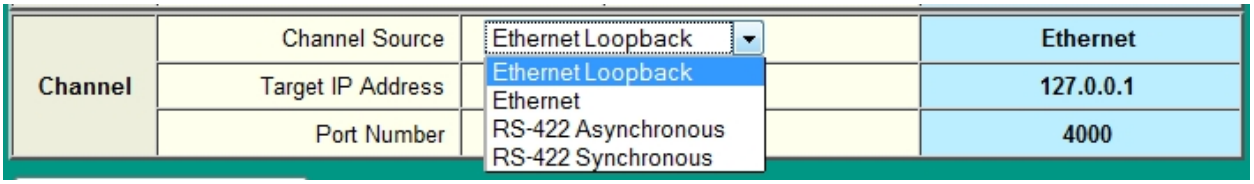

Figure 26 Channel Source Selections

4.11.1.1 Ethernet Loopback (Local)

In loopback communications mode the Net-2000™-VCU will encode speech received on the selected voice source input (Handset 4-Wire or 2-Wire) and play out the encoded/decoded speech on the handset and Line-Out interface. This channel selection is useful when encoding / decoding recorded voice samples as a quick analysis of the selected vocoder.

When Loopback communications mode is selected the Net-2000™-VCU sends data over the internal loopback Ethernet address of 127.0.0.1 Loopback can also be accessed by entering in the IP or host name of the Net-2000™-VCU in the Target IP address box.

4.11.1.2 Ethernet Channel Source Interfaces

Selecting Ethernet as the Channel source allows the Net-2000™-VCU to communicate to another device across an Ethernet network.

When running in VOIP Mode the VCU encodes a frame of speech from the specified voice interface and sends the encoded data over the Ethernet channel interface to the target IP address. At the same time the VCU expects to receive packets from the Ethernet communications channel interface that contains a decode command and encoded data.

4.11.1.3 RS-422 Asynchronous and RS-422 Synchronous Interfaces

When either of the RS-422 interfaces are selected the Net-2000™-VCU encodes speech received on the selected voice source input (Handset 4-Wire or 2-Wire) sends out the encoded speech data over the selected RS-422 interface. This channel selection is useful when encoding / decoding voice between two Net-2000™-VCU that are not located far apart. Two Net-2000™-VCU units can be easily connected together using the Asynchronous connection and a crossover CAT5 cable. See Section 5 for connector pinout details.

In VOIP mode the Net-2000™-VCU also transmits packets over the asynchronous RS-422 interface when the Ethernet interface is the channel source. This is a useful method to monitor the Net-2000™-VCU channel data.

NOTE: DO NOT attempt to connect or use the RS-422 Asynchronous and RS-422 Synchronous ports at the same time.

4.11.2 Target IP Address

The Net-2000™-VCU can communication with another NET-2000™. To communicate (encode and decode to / from) to another Net-2000™-VCU via Ethernet first select Ethernet as the Channel source. Next enter the IP address or host name of the remote unit you are connecting to, in the Target IP address box located under the Channel source pull down menu.

4.11.3 Port Number

The network settings page allows the operator to change the network port number for the communication channel. The default port number is Port 4000. If a different port number is required enter in the desired port number and select the configure button. Valid port numbers are greater than 1024 and less than 65535. Port numbers 4001, 4002 and 4003 are reserved by the Net-2000™-VCU and must not be used.

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5 File Mode

In File mode the Net-2000™-VCU is available for communication with a PC on an Ethernet LAN in order to send data to be encoded or decoded. To set the Net-2000™-VCU to be in file I/O mode select File Mode from the top menu of the Net-2000™-VCU home page. Once selected select the start button and the Net-2000™-VCU will be ready in File Mode.

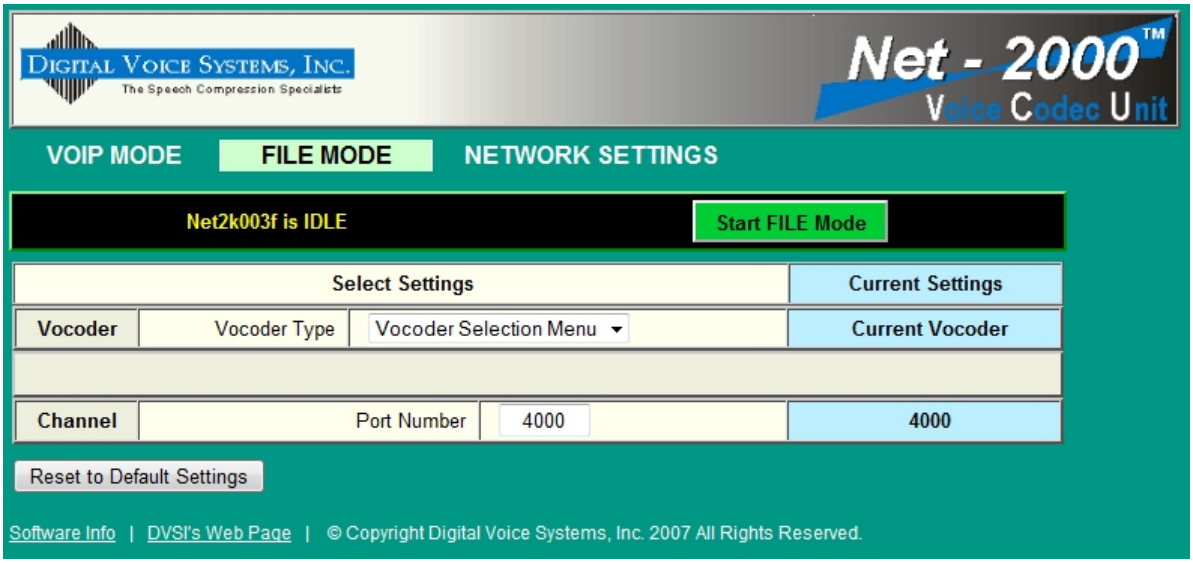

Figure 27 File Mode Web Page

5.1 Vocoder Type Selection

The vocoder type selection sets the Net-2000™-VCU to be ready to encode or decode packets that correspond to the selected vocoder.

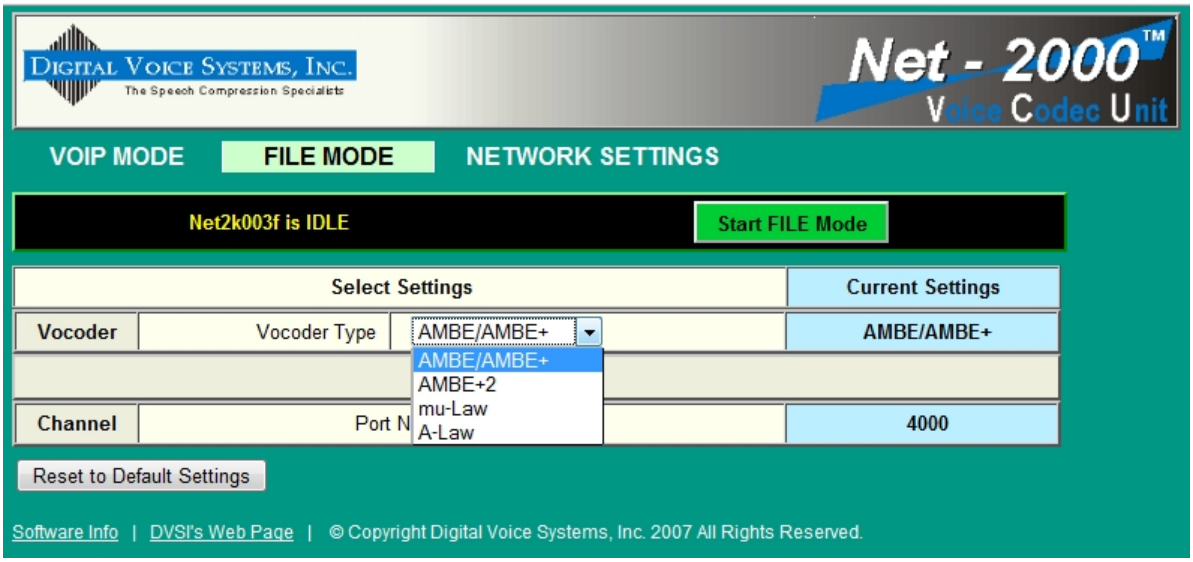

Figure 28 AMBE® / AMBE+™ Version File Mode Selection

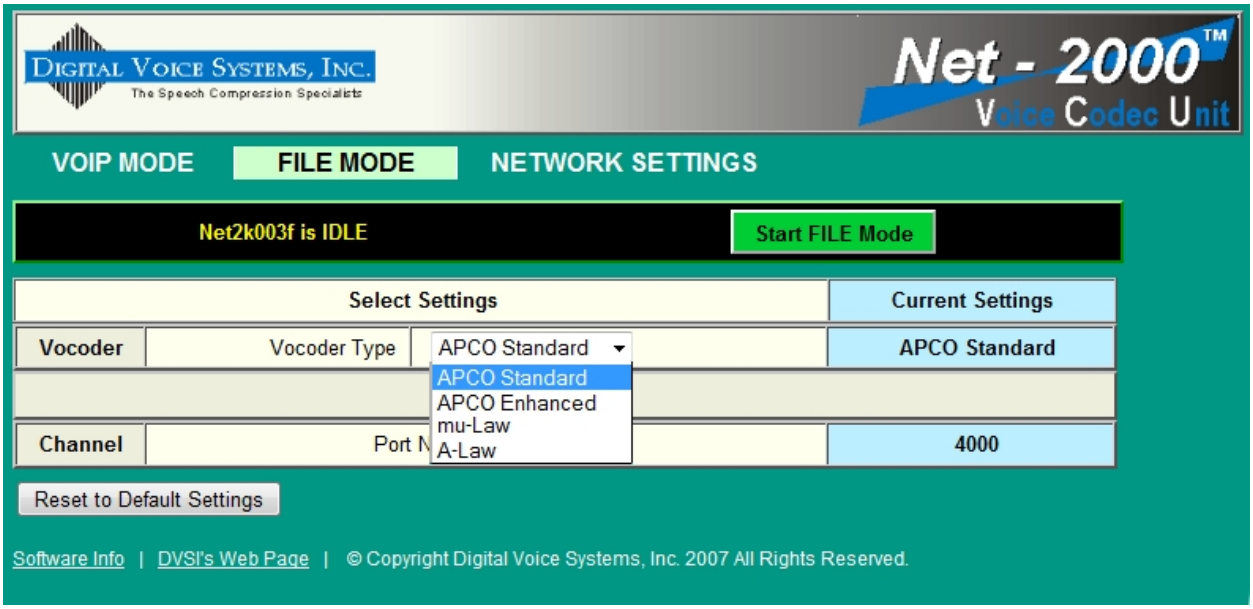

Figure 29 APCO Version File Mode Selection

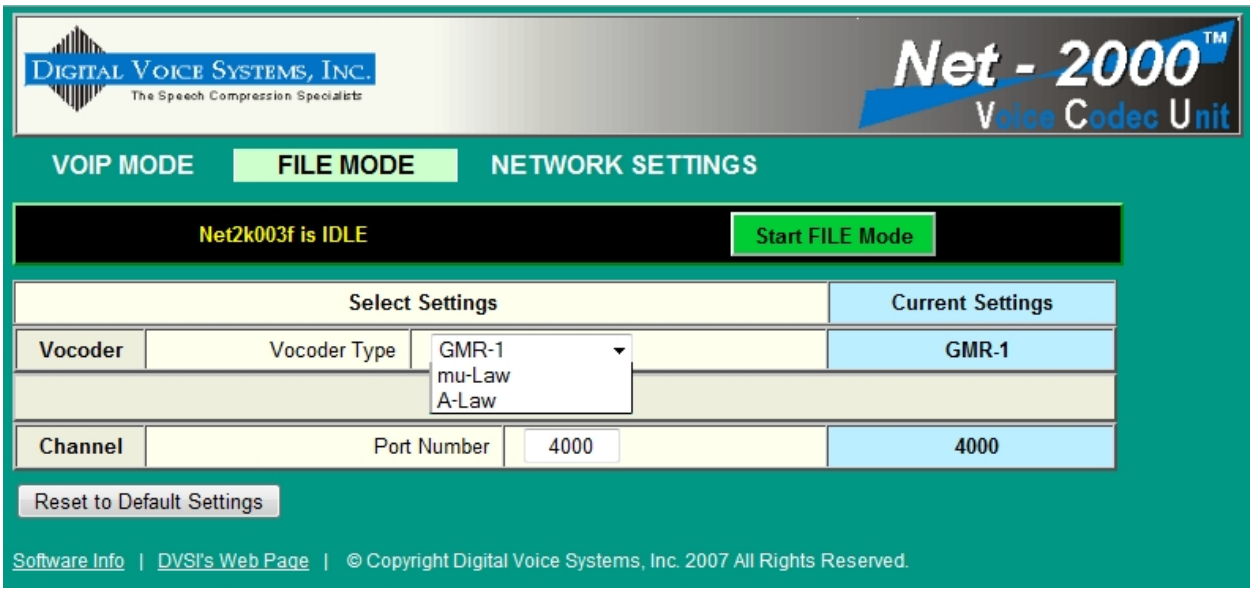

Figure 30 GMR-1 Version File Mode Selection

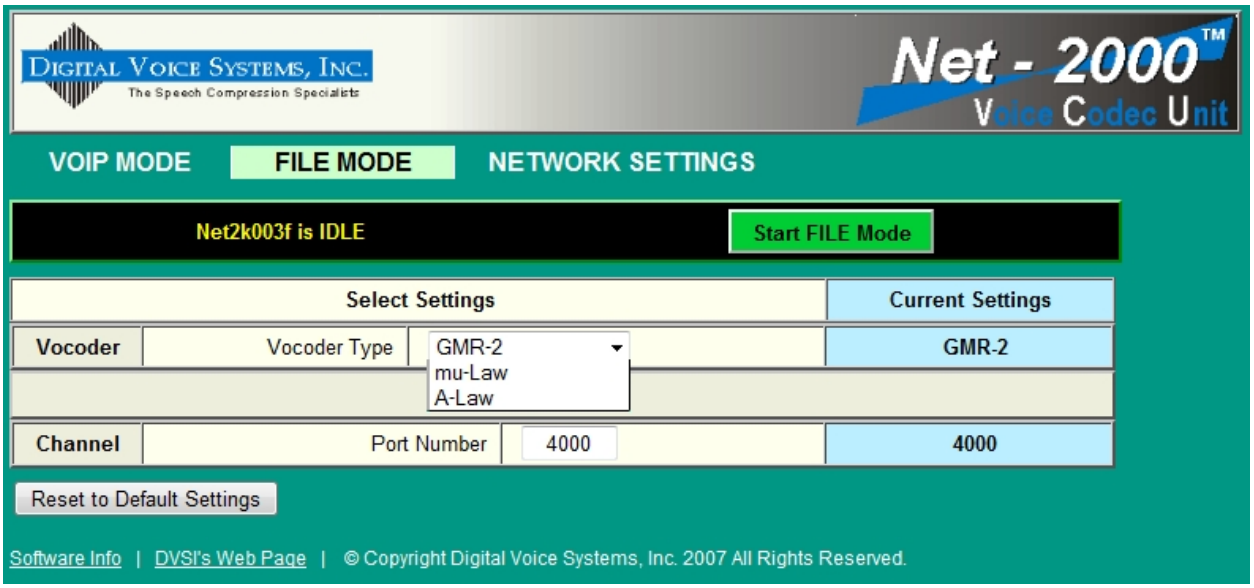

Figure 31 GMR-2 Version File Mode Selection

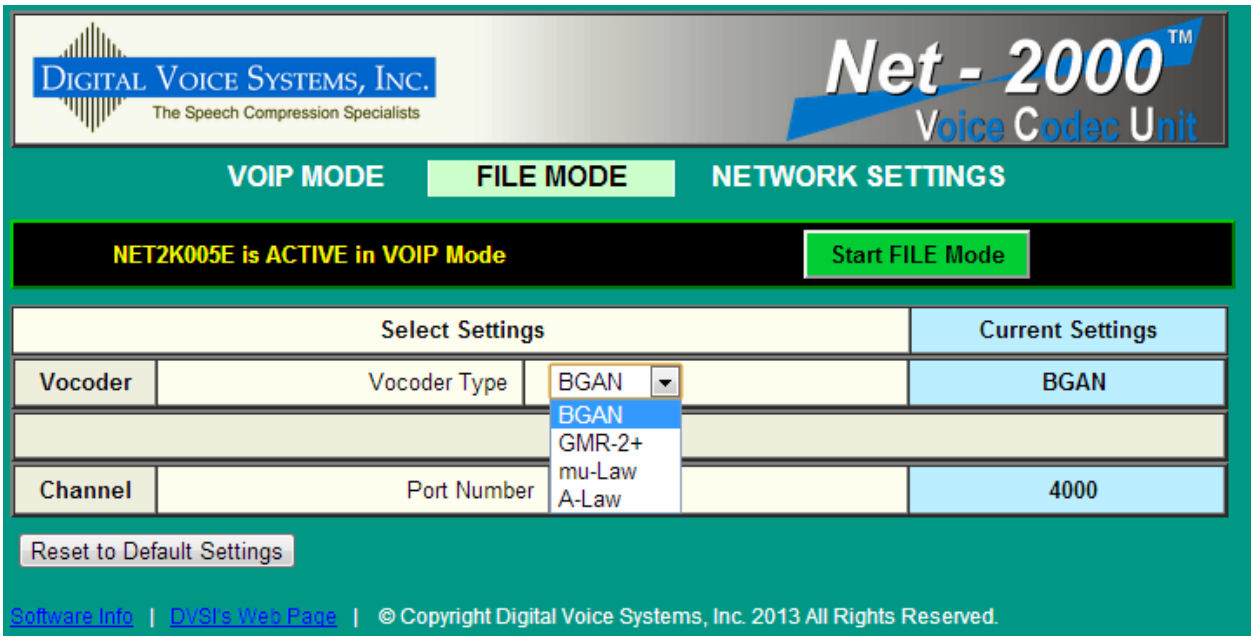

Figure 32 BGAN and GMR-2+ Version File Mode Selection

5.2 Channel Selection Port Number

The network settings page allows the operator to change the network port number for the communication channel. The default port number is Port 4000. If a different port number is required enter in the desired port number and select the configure button. Valid port numbers are greater than 1024 and less than 65535. Port numbers 4001, 4002 and 4003 are reserved by the Net-2000™-VCU and must not be used.

5.3 Processing Files with the Net-2000™-VCU Software

Note: There is PC source code provided on the included CD that interfaces to the Net-2000™-VCU in File Mode. The README on the disc describe how to build and run the PC software example.

The PC program allows users to encode speech to a file and decode channel data from a file. The file mode works in conjunction with software provided by DVSI that runs on a PC. To work in file mode you first have to load the PC software onto a PC connected to an Ethernet network that has access to the Net-2000™-VCU. Set the Net-2000™-VCU to file mode and the unit is now ready to accept packets from the PC using the PC program.

The PC program can run in Windows command prompt (DOS) window. It is comprised of commands that contain the name of the file to be run and the address of the Net-2000™-VCU that will process it. The Net-2000™-VCU can process one file at a time. Customized PC software can be written using the Protocol information that is described in section 4.

In this mode when the Net-2000 receives a packet it processes it and returns a packet. If the packet is PCM data the Net-2000 will encode it and return an encoded packet. . If the packet is encoded data the Net-2000 will decode it and return and PCM packet.

When encoding packets the input to the Net-2000 should be raw 16-bit linear PCM samples in little-endian (PC) byte-order. No headers or format descriptions should be included in the file, only the 8 kHz samples. The Net-2000 will return an encoded packet that contains the vocoder bits with one byte per vocoder bit. The Net-2000 encoder output is always hard-decision -- i.e., each byte in the output file will either take the value zero (0) or one (1).

When decoding a packet of data make sure to set the vocoder type to be the same as the vocoder that encoded the data. Otherwise, the Net-2000™-VCU will see the data as invalid and return silence.

5.4 FILE Mode PC-executable Program

The PC executable program is included with the Net-2000™-VCU. To install the PC software, first create a directory called Net2000 and copy the contents of the floppy disk to it. To run the PC program, open up a command prompt window, change to the Net2000 directory and run the net2k_file.exe file.

Configuration options for the executable are as follows:
-ip <ipaddr>
-r <vocoder_type><vocoder_rate>
-e <encoder_input_file> <encoder_output_file>
-d <decoder_input_file> <decoder_output_file>
-l <loopback_input_file> <loopback_output_file>
-f <encoder_input_file> <encoder_output_file> <decoder_input_file> <decoder_output_file>
****NOTE: When using the -f (full-duplex option the encoder_output_file> and the <decoder_input_file> cannot be the same file. The file will be processed and save to the same directory that the PC executable software is located.
-sdbits <soft_decision_bits>
-cmode <4 digit hexadecimal cmode value for encoder (eg 0xf0a1) See table below

Vocoders	Default cmode Values	VAD_ENABLE	VAD_LEVEL	TONE_DET_ENABLE 0x1000	NS_ENABLE 0x0040	AGC_ENABLE 0x2000	HPD_ENABLE 0x0200 (GMR-2+)	DTX_ENABLE 0x0800
AMBE® AMBE+™	0x1000	ON	-25	ON	N/A	N/A	N/A	N/A
AMBE+2™	0x1040	ON	-25	ON	ON	N/A	N/A	N/A
APCO Standard	0x0000	N/A	0	N/A	N/A	N/A	N/A	N/A
APCO Enhanced	0x1040	ON	0	ON	ON	OFF	N/A	N/A
GMR-1 Vocoder	0x1040	ON	-20	ON	N/A	N/A	N/A	N/A
GMR-2 Vocoder	0x1040	ON	-25	ON	N/A	N/A	N/A	N/A
BGAN Vocoder	0x1040	ON	-20	ON	ON	N/A	N/A	OFF
GMR-2+ Vocoder	0x1240	ON	0	ON	ON	OFF	ON	OFF

Table 7 cmode default values

To select more than one vocoder option at a time you must AND the desired ON /OFF values
The VAD level is set at the recommended value and should typically not be changed.

5.4.1 EXAMPLE (encode):

To encode a file of 16-bit PCM 8kHz voice samples to bits use the following command (on a single line):

net2k_file -ip <net2k_ip_addr> -r <vocoder_type>,<index_no> -e <input_file> <output_file>

where
<net2k_ip_addr> is the IP address of the net2k

(DEPENDING ON WHICH VOCODER IS IMPLEMENTED IN THE NET-2000)

<vocoder_type> is either one of the following
"ambe+2t,00" for GMR-1 at 4000 bps source 1200 bps FEC
or "ambe+2t,01" for GMR-1 at 4000 bps source 0 bps FEC
or "ambemm,01" for GMR-2 at 3600 bps source 0 bps FEC
or "ambe2000,<index_no>" where 0 <= <index_no> < 32 for AMBE-2000 compatible Rates
or "ambe+2,<index_no>" where 48 <= <index_no> < 64 for AMBE+2 rates
or "ambe+2a,<index_no>" where 0 <= <index_no> <= 3 for APCO Enhanced rates
or "ambe+2i,0" for BGAN rate of 4000 bps / 0 bps FEC
or "ambe+2g,<index_no>" for GMR-2+ where <index_no> sets the following rates
<index_no> = 0 for 6000 bps (2450 bps src / 3550 bps FEC)
<index_no> = 1 for 2450 bps (2450 bps src / 0 bps FEC)
<index_no> = 2 for Bit Steal 1 Bit (2450 bps src / 3550 bps FEC)
<index_no> = 6 for Bit Steal 1 Bit (2450 bps src / 0 bps FEC)

or "apco,0" for Standard APCO rate at 4400 bps source and 2800 bps FEC
or "apco,1" for Standard APCO rate at 4400 bps source and 0 bps FEC
or "u-law"
or "a-law"

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<input_file> is the file containing the 16-bit linear PCM

<output_file> is the file to write channel bits to

> **NOTE:**
> The Net-2000 MUST be running in File mode before executing this program.

The input files when encoding should be raw 16-bit linear PCM samples in little-endian (PC) byte-order. No headers or format descriptions should be included in the file, only the 8kHz samples. The output files contain the vocoder bits with one byte per vocoder bit. The net2k encoder output is always hard-decision -- i.e., each byte in the output file will either take the value zero (0) or one (1). For the mu-law and A-law encoder the output is 8-bit mu-law or A-law samples with one byte per sample.

5.4.2 EXAMPLE (decode):

To decode an encoder output file into synthesized speech use the following command:

net2k_file -ip <net2k_ip_addr> -r <vocoder_type>,<index_no.> -sdbits <n_sdbits> -d <input_file> <output_file>

where
<net2k_ip_addr> is the IP address of the net2k
<vocoder_type> SEE ABOVE LIST
Soft Decision ONLY applies to the AMBE+™, AMBE+2™ , GMR-1 and GMR-2+ Vocoders
<n_sdbits> are the number of soft-decision bits per channel bit (1-4)
<input_file> is the input file for the decoder
<output_file> is the output file for the decoder

Input files should contain one channel bit per byte scaled to the desired number of soft-decision bits. For example, if one soft-decision bit is used each byte should take the value zero (0) or one (1). If eight soft decision bits are used, the most confident zero is zero (0x00) and the most confident one is 255 (0xff). Output files are in raw 16-bit linear pcm with no headers or format descriptions. For the mu-law and A-law decoders the channel data is assumed to contain one mu-law or A-law sample in each byte.

6 Interface Protocol

The VCU implements a channel data interface using a special protocol designed by DVSI. The Net-2000™-VCU VCU packet is described from the point-of view of the Net-2000™-VCU.

6.1 Serial Port Protocol

The RS-422 interface protocol is exactly the same as the Ethernet protocol interface but, with an extra 16-bit sync word so that sync up can done in the middle of a transmission.

6.2 Ethernet Protocol

The Net-2000™-VCU uses port 4000 for communication of channel and voice data across the Ethernet interface.

Port 4000 -- the Net-2000™-VCU sends channel/voice data over this port when the channel/voice interface is Ethernet. It also uses this port for vocoder commands. The default port number is 4000, but a different port number can be assigned by using the web interface control and selecting the Net-2000™-VCU settings button.

> **Note:** Port numbers 4001, 4002 and 4003 are reserved by the Net-2000™-VCU and must not be used. Valid port numbers are greater than 1024 and less than 65535.

6.3 Packet Protocol Description

The Ethernet protocol of the Net-2000™-VCU's uses port 4000. Byte order for all 16-bit data types ("short" in the C-language data structure) is network order (big endian), so bytes with lower indexes are the most significant. Since PC's are little endian machines it is necessary to byte-swap when using this protocol with a PC.

The VCU utilizes two categories of packets: *Command Packets* and *Response Packets*. Command Packets are received by a VCU from another VCU in VOIP mode or from a connected PC in File Mode. Command Packets direct a VCU to perform a specific action such as decoding or encoding voice data or performing a reset operation. Response Packets are generated by a VCU and are either the result of a vocoder operation, a reset operation or an unrecognized received packet. Command and Response Packets have five different formats:

Channel Data Packets
Contains channel data output by the VCU encoder (coded speech) or input to the VCU decoder to synthesize speech. **Decode Command Packets** and **Channel Response Packets** use the Channel Data Packet format.

Voice Data Packets
Contains 8kHz sample rate 16 bit PCM voice data that are inputs to the VCU encoder or are synthesized outputs of the VCU decoder. **Encode Command Packets** and **Voice Response Packets** use the Voice Data Packet format.

Reset Packets
Reset Packets are used in File Mode to initialize the encoder and/or decoder.

Ack Packets
Ack Packets are used in File Mode to confirm that a Reset Packet was executed successfully.

Nack Packets
Nack Packets are transmitted by the VCU in response to an invalid received packet.

When the VCU is in VOIP Mode it exchanges Decode Command Packets with another VCU in real time to provide a full duplex communication channel. The encoder in a VCU compresses speech from its analog handset and 4-wire sources and transmits it to a receiving VCU using Decode Command Packets. The decoder in the VCU synthesizes the channel data from a received Decode Command Packet into speech and sends it to its analog interfaces.

When the VCU is in File Mode, it monitors port 4000 (or a different port if one has been selected using the web interface) for incoming packets. If a Reset packet is received the VCU resets the encoder and/or decoder as specified in the packet and responds to the packet sender with an ACK packet. If an Encode Command Packet is received the VCU encodes the voice data in the packet and responds to the sender with a Channel Response Packet containing the encoded data. If a Decode Command Packet is received, the VCU decodes the channel data in the packet and responds to the sender with a Voice Response Packet containing synthesized speech. In File Mode it is possible to produce bit-exact, repeatable results for vocoder quality testing.

PC source code is provided on the CD included with the VCU that implements the protocol and can be used with the VCU in File Mode to encode and decode speech.

6.3.1 Packet Header

Every packet in the protocol starts with a six-byte header containing a 16-bit integer indicating the overall length of the packet in bytes, a 16-bit integer indicating the type of the packet, and a 16-bit sequence number. The six-byte packet header for all data packets is shown in Table 8. An “x” is used in all the tables in this description to indicate that a bit can take a value of 0 or 1.

Packet Header				
Bytes (msb-lsb)		16 bit Word 15 14 13 12 11 10 9 8	6 5 4 3 2 1 0	Parameter Name
		Byte (n)	Byte (n+1)	
Header	0 – 1	0 0 0 0 0 0 0 0	x x x x x x x x	len
	2 – 3	0 0 0 0 0 0 0 0	x x x x x x x x	type
	4 – 5	x x x x x x x x	x x x x x x x x	seq

Table 8 Packet Header

Bytes 0 and 1 hold the 16-bit length of the packet (see Table 9 len Header). Maximum packet length is 514 bytes. Bytes 2 and 3 hold the 16-bit packet type (see Table 10 type). Bytes 4 and 5 hold the 16-bit sequence number parameter (see Table 11 seq Header .) The sequence number of a response to a command packet is the command packet sequence number plus one. The sequence number is used as a method to detect that no data packets are dropped, so it is important to ensure that consecutive sequence numbers are transmitted for voice and channel data packets during operation.

len = *Length (in bytes) of total packet (including header)*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 0	Byte 1	Decimal Value
Minimum Value	0 0 0 0 0 0 0 0	0 0 0 0 0 1 1 0	6 bytes
Maximum Value	0 0 0 0 0 0 1 0	0 0 0 0 0 0 0 0	514 bytes

Table 9 len Header Parameter

type = *Packet type*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
Command Packets	Byte 2	Byte 3	Decimal Value
Reset	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0
Encode	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 0	2
Decode	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 1	3
Response Packets	Byte 2	Byte 3	Decimal Value
ACK	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0
NACK	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1	1
Voice	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 0	2
Channel	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 1	3

Table 10 type Header Parameter

seq = *Sequence number**			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 4	Byte 5	Decimal Value
Minimum Value	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	-32768
Reset Start Value	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0
Maximum Value	0 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	32767

Table 11 seq Header Parameter

*Note: Sequence numbers should be incremented by one every time a packet is transmitted. When the sequence number reaches 32767, the next valid sequence number is -32768.

6.3.2 Channel Data Packet

Channel Data Packets contain channel data output by the encoder (coded speech) or are inputs to the decoder to synthesize speech. Decode Command Packets and Channel Response Packets use the Channel Data Packet format.

6.3.2.1 Decode Command Packet

The VCU can receive Decode Command Packet from another VCU in VOIP mode or from a PC in File Mode. In VOIP mode, the VCU decodes the channel data and sends the synthesized speech to the VCU analog outputs. In File Mode, the VCU decodes the channel data and transmits a Voice Response Packet.

6.3.2.2 Channel Response Packet

The VCU transmits a Channel Response Packet to a PC in File Mode after encoding a received Encode Command Packet.

6.3.2.3 Channel Data Packet Format

Channel Packet (220 bytes)				
Bytes		16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
Header	0 - 1	0 0 0 0 0 0 0 0	1 1 0 1 1 0 1 0	len
	2 - 3	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 1	type
	4 - 5	x x x x x x x x	x x x x x x x x	seq
6 - 7		x x x x x x x x	x x x x x x x x	rate [0]
8 - 9		x x x x x x x x	x x x x x x x x	rate [1]
10 - 11		x x x x x x x x	x x x x x x x x	rate [2]
12 - 13		x x x x x x x x	x x x x x x x x	rate [3]
14 - 15		x x x x x x x x	x x x x x x x x	rate [4]
16 - 17		x x x x x x x x	1 1 0 0 x x x x	rate [5]
18 - 19		x x 0 0 0 x 0 0	0 0 0 0 x x x 0	cmode
20 - 21		0 0 0 0 0 0 0 0	x x x x x x x x	tone.idx
22 - 23		x x x x x x x x	x x x x x x x x	tone.amp
24 - 25		0 0 0 0 0 0 0 0	1 0 x x x x x x	ws
26 - 27		0 0 0 0 x x x x	0 0 0 x 0 0 x x	format
28 - 29		x x x x x x x x	x x x x x x x x	channel [0-1]
30 - 31		x x x x x x x x	x x x x x x x x	channel [2-3]
32 - 33		x x x x x x x x	x x x x x x x x	channel [4-5]
…		…	…	…
218 - 219		x x x x x x x x	x x x x x x x x	channel [190-191]

Table 12 Channel Data Packet

Channel Data Packets are always 220 bytes and have the following format described in Table 12 and C-language data structure below:

```
struct channel_packet_t {
       short     len;
       short    type;
       short     seq;
       short    rate[6];
       short   cmode;
       short    tone[2];
       short      ws;
       short  format;
       char  channel[192];
};
```

Note that each bit of channel data occupies one byte of the channel[] buffer in the packet. The remaining bytes in the `channel[]` buffer are ignored. The elements of the Decode packet are described in detail in the following sections.

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6.3.2.4 Channel Data Packet Bytes 0 and 1 (len)

The len parameter (bytes 0 and 1) hold the 16-bit length of the packet. The packet length is always 220 bytes.

len = *Length (in bytes) of total packet (including header)*			
	16 bit Word 15 14 13 12 11 10 9 8 Byte 0	7 6 5 4 3 2 1 0 Byte 1	Decimal Value
Data Packet Size	0 0 0 0 0 0 0 0	1 1 0 1 1 1 0 0	220 bytes

Table 13 len Header Parameter

6.3.2.5 Channel Data Packet Bytes 2 and 3 (type)

The type parameter (bytes 2 and 3) is 16-bits packet type and is always 0x0003 for channel data.

type = *Packet type*			
	16 bit Word 15 14 13 12 11 10 9 8 Byte 2	7 6 5 4 3 2 1 0 Byte 3	Hex Value
Channel Data	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 1	0x0003

Table 14 type Header Parameter

6.3.2.6 Channel Data Packet Bytes 4 and 5 (seq)

Bytes 4 and 5 hold the 16-bit sequence number. The sequence number is used as a method to detect if and when data packets are dropped, so it is important to ensure that consecutive sequence numbers are transmitted for channel data packets during operation.

seq = *Sequence number**			
	16 bit Word 15 14 13 12 11 10 9 8 Byte 4	7 6 5 4 3 2 1 0 Byte 5	Decimal Value
Minimum Value	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	-32768
Maximum Value	0 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	32767

Table 15 seq Header Parameter

Note: Sequence numbers should be incremented by one every time a packet is transmitted. When the sequence number reaches 32767, the next valid sequence number is -32768.

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6.3.2.7 Channel Data Packet Bytes 6 to 17 (rate[0-5])

There are six rate information words and four parameter words that are common to the Encode Command Packet, Decode Command Packet, Voice Response Packet and the Channel Response Packet. These are described below.

rate [6] vocoder rate and type			
Bytes	16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
…	…	…	…
6 - 7	x x x x x x x x	x x x x x x x x	rate [0]
8 - 9	x x x x x x x x	x x x x x x x x	rate [1]
10 - 11	x x x x x x x x	x x x x x x x x	rate [2]
12 - 13	x x x x x x x x	x x x x x x x x	rate [3]
14 - 15	x x x x x x x x	x x x x x x x x	rate [4]
16 - 17	x x x x x x x x	1 1 0 0 x x x x	rate [5]
…	…	…	…

Table 16 rate[0-5] Parameter

The six Rate words contain information of the vocoder and data/FEC rate details. This information will vary for the types of vocoders. Rate information can be decoded as follows:

the bottom 8 bits of rate[0] contains the number of speech data bits-per-frame, (1 frame=20 ms)
the bottom 8 bits of rate[5] contains the total number of bits per frame (speech data bits plus FEC data bits)
the top 8 bits of rate[5] specifies the vocoder type:

NOTE: the mu-law and A-law coder use each byte in the channel data packet for a mu-law or A-law sample. The soft-decision bits value in the packet should always be set to 8 for the mu-law or A-law coder.

For the AMBE® / AMBE+™ vocoders
the top 8 bits of rate[5] = `0xC0 , (<vocoder_type> = ambe2000)`

For the AMBE+2™ vocoder
the top 8 bits of rate[5] = `0xC1 , (<vocoder_type> = ambe+2)`

For the APCO Standard vocoder
the top 8 bits of rate[5] = `0xC2 , (<vocoder_type> = apco)`

For the APCO Enhanced vocoder
the top 8 bits of rate[5] = `0xC3 , (<vocoder_type> = ambe+2a)`

For the BGAN vocoder
the top 8 bits of rate[5] = `0xC8 , (<vocoder_type> = ambe+2i)`

For the GMR-2+ vocoder
the top 8 bits of rate[5] = `0xC8 , (<vocoder_type> = ambe+2g)`

For the GMR-1 vocoder
the top 8 bits of rate[5] = `0xC8 , (<vocoder_type> = ambe+2t)`

For the GMR-2 vocoder
the top 8 bits of rate[5] = `0xC9 , (<vocoder_type> = ambemm)`

For the u-law vocoder
the top 8 bits of rate[5] = `0xC5 , (<vocoder_type> = u-law)`

For the a-law vocoder
the top 8 bits of rate[5] = `0xC6 , (<vocoder_type> = a-law)`

All others are reserved.

Total Rate (bps)	Speech Rate (bps)	FEC Rate (bps)	rate_[0]	rate_[1]	rate_[2]	rate_[3]	rate_ [4]	rate_ [5]	Index
2000	2000	0	0x0028	0x0000	0x0000	0x0000	0x6428	0xc028	31
2400	2400	0	0x9030	0x0000	0x0000	0x0000	0x4330	0xc030	0
	2350	50	0x902f	0x0000	0x0000	0x0000	0x6930	0xc030	5
3000	3000	0	0x043c	0x0986	0x0000	0x0000	0x0000	0xc13c	63
3600	3600	0	0x9348	0x0000	0x0000	0x0000	0x6f48	0xc048	1
	3350	250	0x9243	0x0080	0x0000	0x0000	0x5348	0xc048	11
	3600	0	0x5048	0x0000	0x0000	0x0000	0x3948	0xc048	16
	3600	0	0x0448	0x0986	0x0000	0x0000	0x0000	0xc148	48
4000	4000	0	0xab50	0x0000	0x0000	0x0000	0x3950	0xc050	15
	3750	250	0x934b	0x0080	0x0000	0x0000	0x3950	0xc050	14
	4000	0	0x5250	0x0000	0x0000	0x0000	0x4150	0xc050	17
	2400	1600	0x1030	0x0001	0x0000	0x341a	0x6750	0xc050	22
	4000	0	0x0450	0x0986	0x0000	0x0000	0x0000	0xc150	49
	2400	1600	0x0430	0x0986	0x0001	0x0000	0x341a	0xc150	54
4800	4800	0	0xab60	0x0000	0x0000	0x0000	0x7960	0xc060	3
	4550	250	0xab5b	0x0080	0x0000	0x0000	0x6860	0xc060	7
	3600	1200	0x9348	0x2030	0x0000	0x0000	0x7060	0xc060	2
	3100	1700	0x923e	0x2800	0x0000	0x0000	0x7460	0xc060	8
	4800	0	0x5360	0x0000	0x0000	0x0000	0x6c60	0xc060	18
	4000	800	0x5250	0x2010	0x0000	0x0000	0x7460	0xc060	24
	3600	1200	0x5048	0x0001	0x0000	0x2412	0x6860	0xc060	23
	2400	2400	0x1030	0x0005	0x180c	0x3018	0x7360	0xc060	25
	4800	0	0x0460	0x0986	0x0000	0x0000	0x0000	0xc160	50
	4000	800	0x0450	0x0986	0x2010	0x0000	0x0000	0xc160	56
	3600	1200	0x0448	0x0986	0x0001	0x2412	0x0000	0xc160	55
	2400	2400	0x0430	0x0986	0x0005	0x180c	0x3018	0xc160	57
6400	4150	2250	0xab53	0x2c00	0x0000	0x0000	0x5680	0xc080	10
	6400	0	0x6b80	0x0000	0x0000	0x0000	0x6c80	0xc080	19
	4000	2400	0x5250	0x0001	0x0000	0x542a	0x5280	0xc080	26
	6400	0	0x0480	0x0986	0x0000	0x0000	0x0000	0xc180	51
	4000	2400	0x0450	0x0986	0x0001	0x0000	0x542a	0xc180	58

7200	4400	2800	0xab58	0x3000	0x0000	0x0000	0x4490	0xc090	9
	4400	2800	0x5258	0x0009	0x1e0c	0x4127	0x7390	0xc090	27
	4400	2800	0x0458	0x0986	0x0009	0x1e0c	0x4127	0xc190	59
8000	7750	250	0xbf9b	0x0080	0x0000	0x0000	0x49a0	0xc0a0	12
	4650	3350	0xab5d	0x3400	0x0000	0x0000	0x31a0	0xc0a0	13
	8000	0	0x7fa0	0x0000	0x0000	0x0000	0x52a0	0xc0a0	20
	4000	4000	0x5250	0x0005	0x2010	0x6834	0x72a0	0xc0a0	28
	8000	0	0x04a0	0x0986	0x0000	0x0000	0x0000	0xc1a0	52
	4000	4000	0x0450	0x0986	0x0005	0x2010	0x6834	0xc1a0	60
9600	9600	0	0xbfc0	0x0000	0x0000	0x0000	0x72c0	0xc0c0	4
	4850	4750	0xab61	0xe400	0x0000	0x0000	0x67c0	0xc0c0	6
	9600	0	0x7fc0	0x0000	0x0000	0x0000	0x69c0	0xc0c0	21
	3600	6000	0x5048	0x000e	0x4010	0x6a2e	0x65c0	0xc0c0	30
	2400	7200	0x1030	0x000e	0x681a	0x511b	0x76c0	0xc0c0	29
	9600	0	0x04c0	0x0986	0x0000	0x0000	0x0000	0xc1c0	53
	3600	6000	0x0448	0x0986	0x000e	0x4010	0x6a2e	0xc1c0	62
	2400	7200	0x0430	0x0986	0x000e	0x681a	0x511b	0xc1c0	61

Table 17 AMBE® / AMBE+™ / AMBE+2™ Rate Table

Total Rate (bps)	Speech Rate (bps)	FEC Rate (bps)	rate_[0]	rate_[1]	rate_[2]	rate_[3]	rate_ [4]	rate_ [5]	Index
7200	4400	2800	0x0058	0x0000	0x0000	0x0000	0x0000	0xc290	0
4400	4400	0	0x0058	0x0000	0x0000	0x0000	0x0000	0xc258	1
7200	4400	2800	0x0058	0x0000	0x0000	0x0000	0x0000	0xc390	0
4400	4400	0	0x0058	0x0000	0x0000	0x0000	0x0000	0xc358	1
3600	2450	1150	0x0031	0x0000	0x0000	0x0000	0x0000	0xc348	2
2450	2450	0	0x0031	0x0000	0x0000	0x0000	0x0000	0xc331	3

Table 18 APCO Standard and APCO Enhanced Rate Table

Total Rate (bps)	Speech Rate (bps)	FEC Rate (bps)	rate_[0]	rate_[1]	rate_[2]	rate_[3]	rate_ [4]	rate_ [5]	Index
5200	4000	1200	0x0050	0x0000	0x0000	0x0000	0x0000	0xc868	0
4000	4000	0	0x0050	0x0000	0x0000	0x0000	0x0000	0xc850	1
3600	3600	0	0x0048	0x0000	0x0000	0x0000	0x0000	0xc948	1

Table 19 GMR-1 and GMR-2 Rate Table

Total Rate (bps)	Speech Rate (bps)	FEC Rate (bps)	rate_[0]	rate_[1]	rate_[2]	rate_[3]	rate_ [4]	rate_ [5]	Index
3600	4000	0	0x0050	0x0000	0x0000	0x0000	0x0000	0xc450	0
6000	2450	3550	0x0031	0x0000	0x0000	0x0000	0x0000	0xca78	0
2450	2450	0	0x0031	0x0000	0x0000	0x0000	0x0000	0xca31	1
6000	2450	3550	0x0031	0x0000	0x0000	0x0000	0x0000	0xca78	2
2450	2450	0	0x0031	0x0000	0x0000	0x0000	0x0000	0xca31	6

Table 20 BGAN and GMR-2+ Rate Table

Table Key
AMBE® Vocoder
AMBE+™ Vocoder
AMBE+2™ Vocoder
APCO Standard Vocoder
APCO Enhanced Vocoder
GMR-1 Vocoder
GMR-2 Vocoder
BGAN Vocoder
GMR-2+ Vocoder

Table 21 Rate Tables Key

6.3.2.8 Channel Data Packet Bytes 18 and 19 (cmode)

The cmode element of a Channel Data Packet contains the input command flags to the decoder when it is received by a VCU or the output status flags of the encoder when it is transmitted by a VCU. Table 22 and Table 23 list values for the decoder input and encoder output flags of a Channel Data Packet.

cmode parameter			
Decoder Input Flags	16 bit Word 15 14 13 12 11 10 9 8 Byte 18	7 6 5 4 3 2 1 0 Byte 19	Hex Value
Nominal Value	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x0000
AMBE_LOST_FRAME_FLAG	0 0 0 0 0 0 0 0	0 0 0 0 0 1 0 0	0x0004
AMBE_CNI_FRAME_FLAG	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	0x0008
AMBE_DTMF_SEND_FLAG	0 1 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x4000

Table 22 cmode Parameter (Used in the Decoder Command Packet)

The nominal value for the cmode parameter should be zero when sending Channel Data Packets to the VCU. The decoder will perform a frame repeat when the AMBE_LOST_FRAME_FLAG is set. The decoder will generate comfort noise (i.e., mute) when the AMBE_CNI_FRAME_FLAG is set. The decoder will ignore the channel data in the packet and generate a tone when the AMBE_DTMF_SEND_FLAG is set. The index and amplitude of the

tone is set in the tone.idx and tone.amp parameters of the Channel Data Packet. The a-Law and U-Law decoders do not support tone signaling and ignore the AMBE_DTMF_SEND_FLAG.

cmode parameter			
Encoder Output Flags	16 bit Word 15 14 13 12 11 10 9 8 Byte 18	7 6 5 4 3 2 1 0 Byte 19	Hex Value
AMBE_VOICE_ACTIVE_FLAG	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 0	0x0002
AMBE_VAD_FLAG	0 0 0 0 0 1 0 0	0 0 0 0 0 0 0 0	0x0400
AMBE_DTMF_FRAME_FLAG	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x8000

Table 23 cmode Parameter (Used in the Channel Response Packet)

When the VCU transmits Channel Data Packets it sets the cmode parameter with the flags returned by the encoder. The AMBE_VOICE_ACTIVE_FLAG is set when the packet must be transmitted to the decoder (if cleared and DTX is in use the frame does not need to be transmitted). If the AMBE_VAD_FLAG is set the packet contains voice data (if cleared the frame is a silence frame). If the AMBE_DTMF_FRAME_FLAG flag is set the packet contains tone data. The index and amplitude of the tone are reported in the tone.idx and tone.amp parameters of the Channel Data Packet (see Table 24 tone.idx Parameter and Table 25 tone.idx Parameter (cont'd)).

The AMBE/AMBE+™ and AMBE+2™ coders both support the DTMF_FRAME_FLAG.

The AMBE+2™ coder supports the AMBE_VAD_FLAG.

The AMBE/AMBE+™ coder does not support the AMBE_VAD_FLAG flag and uses the AMBE_VOICE_ACTIVE_FLAG flag for that function. The AMBE/AMBE+™ coder does not have a flag to indicate whether the packet should be transmitted. With the AMBE/AMBE+™ coder you must transmit the first silence frame following a frame with AMBE_VOICE_ACTIVE_FLAG set to do DTX.

The GMR-2+ and BGAN vocoders have the VAD set internally and it is always ON.

The mu-law and A-law coders don't support any of these Encoder Output Flags.

6.3.2.9 Channel Data Packet Bytes 20, 21, 22, 23 (tone.idx & tone.amp)

Appropriate values for tone.idx and tone.amp, are listed in Table 24 tone.idx Parameter. When tone signaling is inactive tone.idx should be set to NO TONE and tone.amp should be set to zero.

Vocoder tone.idx					
Description	Frequency (Hz)	16 bit Word shown for (AMBE® / AMBE+™ / ABME+2™/ GMR-1) 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0		AMBE® / AMBE+™ / ABME+2™/ GMR-1	**BGAN**
		Byte 20	Byte 21	Decimal Value	
not used	NA	NA	NA	0 - 4	0 - 4
Single Tones 156.25 to 3812.5 Hz	31.25 (tone.idx)	0 0 0 0 0 0 0 0	0 x x x x x x x	5 - 122	5 - 122
not used	NA	NA	NA	123 - 127	123 - 127
DTMF “0”	1336, 941	0 0 0 0 0 0 0 0	1 0 0 0 0 1 1 1	135	135
DTMF “1”	1209, 697	0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0	128	128
DTMF “2”	1336, 697	0 0 0 0 0 0 0 0	1 0 0 0 0 1 0 0	132	132
DTMF “3”	1477, 697	0 0 0 0 0 0 0 0	1 0 0 0 1 0 0 0	136	136
DTMF “4”	1209, 770	0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 1	129	129
DTMF “5”	1336, 770	0 0 0 0 0 0 0 0	1 0 0 0 0 1 0 1	133	133
DTMF “6”	1477, 770	0 0 0 0 0 0 0 0	1 0 0 0 1 0 0 1	137	137
DTMF “7”	1209, 852	0 0 0 0 0 0 0 0	1 0 0 0 0 0 1 0	130	130
DTMF “8”	1336, 852	0 0 0 0 0 0 0 0	1 0 0 0 0 1 1 0	134	134
DTMF “9”	1477, 852	0 0 0 0 0 0 0 0	1 0 0 0 1 0 1 0	138	138
DTMF “A”	1633, 697	0 0 0 0 0 0 0 0	1 0 0 0 1 1 0 0	140	140
DTMF “B”	1633, 770	0 0 0 0 0 0 0 0	1 0 0 0 1 1 0 1	141	141
DTMF “C”	1633, 852	0 0 0 0 0 0 0 0	1 0 0 0 1 1 1 0	142	142
DTMF “D”	1633, 941	0 0 0 0 0 0 0 0	1 0 0 0 1 1 1 1	143	143
DTMF “*”	1209, 941	0 0 0 0 0 0 0 0	1 0 0 0 0 0 1 1	131	131
DTMF “#”	1477, 941	0 0 0 0 0 0 0 0	1 0 0 0 1 0 1 1	139	139
Call Progress	440, 350	0 0 0 0 0 0 0 0	1 0 0 1 0 0 0 0	144	144
Call Progress	480, 440	0 0 0 0 0 0 0 0	1 0 0 1 0 0 0 1	145	145
Call Progress	620, 480	0 0 0 0 0 0 0 0	1 0 0 1 0 0 1 0	146	146
Call Progress	490, 350	NA	NA	NA	147
not used	NA	NA	NA	147-254	148-254
INVALID TONE	n/a	0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1	255	255

Table 24 tone.idx Parameter

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Vocoder tone.idx			
Description	Frequency (Hz)	APCO APCO Enchanced GMR-2+	**GMR-2 Only**
		DecimalValue	
not used	NA	0 - 4	NA
Single Tones 156.25 to 3812.5 Hz	31.25 (tone.idx)	5 - 122	NA
not used	NA	123 - 127	123 - 127
DTMF “0”	1336, 941	128	7
DTMF “1”	1209, 697	129	0
DTMF “2”	1336, 697	130	4
DTMF “3”	1477, 697	131	8
DTMF “4”	1209, 770	132	1
DTMF “5”	1336, 770	133	5
DTMF “6”	1477, 770	134	9
DTMF “7”	1209, 852	135	2
DTMF “8”	1336, 852	136	6
DTMF “9”	1477, 852	137	10
DTMF “A”	1633, 697	138	12
DTMF “B”	1633, 770	139	13
DTMF “C”	1633, 852	140	14
DTMF “D”	1633, 941	141	15
DTMF “*”	1209, 941	142	3
DTMF “#”	1477, 941	143	11
KNOX “0”	1162, 820	144	NA
KNOX “1”	1052, 606	145	NA
KNOX “2”	1162, 606	146	NA
KNOX “3”	1279, 606	147	NA
KNOX “4”	1052, 672	148	NA
KNOX “5”	1162, 672	149	NA
KNOX “6”	1279, 672	150	NA
KNOX “7”	1052, 743	151	NA
KNOX “8”	1162, 743	152	NA
KNOX “9”	1279, 743	153	NA
KNOX “A”	1430, 606	154	NA
KNOX “B”	1430, 672	155	NA
KNOX “C”	1430, 743	156	NA
KNOX “D”	1430, 820	157	NA
KNOX “*”	1052, 820	158	NA
KNOX “#”	1279, 820	159	NA
Call Progress	440, 350	160	NA
Call Progress	480, 440	161	NA
Call Progress	620, 480	162	NA
Call Progress	490, 350	163	
not used	NA	164-254	147-254
INVALID TONE	n/a	255	255

Table 25 tone.idx Parameter (cont’d)

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tone.amp = *tone amplitude*			
Description	16 bit Word 15 14 13 12 11 10 9 8 Byte 22	7 6 5 4 3 2 1 0 Byte 23	Decimal Value
Max Amplitude	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 1	+3
…	…	…	…
Zero Amplitude	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0
…	…	…	…
Min. Amplitude	1 0 0 0 0 0 0 0	0 1 0 1 1 0 1 0	-90

Valid range: +3 to -90 (signed twos complement integer, units are dBm0)

Table 26 tone.amp Parameter

6.3.2.10 Channel Data Packet Bytes 24 & 25 (ws)

The ws element of the packet contains the number of voice samples that should be synthesized by the decoder in a Decoder Command Packet or the number of samples that were used to encode the channel data in a Channel Response Packet. Appropriate values for ws are listed in Table 27 ws Parameter.

ws = Number of voice samples.			
Description	16 bit Word 15 14 13 12 11 10 9 8 Byte 24	7 6 5 4 3 2 1 0 Byte 25	Decimal Value
	0 0 0 0 0 0 0 0	1 0 0 1 1 1 1 1	159
	0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0	160
	0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 1	161

Table 27 ws Parameter

6.3.2.11 Channel Data Packet Bytes 26 & 27 (format)

Soft Decision ONLY applies to the AMBE+™, AMBE+2™, GMR-1 and GMR-2+ Vocoders. Format includes both the number of soft decision bits in the channel data and the format of the voice data to synthesize. This number of soft decision bits should be between 1 (hard decision) and 4 (maximum soft decision capability). The number of soft decision bits is determined by the top 8 bits of the format element.

(format >> 8) & 0x00ff

The format element of the channel packet also indicates the format of the voice data to be generated by the decoder. Appropriate values for the number of soft decision bits and voice data type in the format element is listed in Table 28 format Parameter.

format = Soft decision & *voice data*			
Voice Data Formats	16 bit Word 15 14 13 12 11 10 9 8 Byte 26	7 6 5 4 3 2 1 0 Byte 27	Hex Value
Linear 16-bit PCM	0 0 0 0 x x x x	0 0 0 0 0 0 0 0	0xXX00
Soft-Decision Bits	Byte 26 7 6 5 4 3 2 1 0	Byte 27 7 6 5 4 3 2 1 0	Hex Value
1	0 0 0 0 0 0 0 1	0 0 0 x 0 0 x x	0x01XX
2	0 0 0 0 0 0 1 0	0 0 0 x 0 0 x x	0x02XX
3	0 0 0 0 0 0 1 1	0 0 0 x 0 0 x x	0x03XX
4	0 0 0 0 0 1 0 0	0 0 0 x 0 0 x x	0x04XX

Table 28 format Parameter

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The voice data format to synthesize is as follows:
The voice data to be synthesized is 16 bit PCM
(format & 0x000f) == 0x00

All other formats are invalid.

Soft Decision ONLY applies to the AMBE+™, AMBE+2™ , GMR-1 and GMR-2+ Vocoders. If channel[] contains hard decision data (no soft decision error detection)
channel[i] == 0x01 is a one,
channel[i] == 0x00 is a zero

If 4 bit soft decision error detection is used then,
channel[i] == 0x0f is the most confident one
channel[i] = 0x00 is the most confident zero

Other values for the number of soft-decision bits are coded in a similar manner. For transmitting DTX frames a channel data packet must contain all ones in the channel[] array. To signal no data and force a frame repeat the channel[] array data packet must contain all zeros.

6.3.2.12 Channel Data Packet Bytes 28-219 (channel[0-191])

For simplicity, and since channel data packets are small compared to nominal Ethernet frames, all 192 channel bytes are ALWAYS transmitted regardless of the actual bit-rate of the vocoder. Each byte of the channel [] array contains one channel data "bit".

Channel [192]			
Bytes	16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	 7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
…	…	…	…
28 - 29	x x x x x x x x	x x x x x x x x	channel [0-1]
30 – 31	x x x x x x x x	x x x x x x x x	channel [2-3]
32 – 33	x x x x x x x x	x x x x x x x x	channel [4-5]
…	…	…	…
218-219	x x x x x x x x	x x x x x x x x	channel [190-191]

Table 29 channel Parameter

6.3.3 Voice Data Packet

Voice Data Packets contain 8kHz sample rate 16 bit PCM voice data that are inputs to the VCU encoder or are synthesized outputs of the VCU decoder. **Encode Command Packets** and **Voice Response Packets** use the Voice Data Packet format.

6.3.3.1 Encode Command Packet

The VCU can receive an Encode Command Packet from a PC in File Mode. The VCU encodes the voice data and responds by sending a Channel Response Packet to the PC.

6.3.3.2 Voice Response Packet

The VCU transmits a Voice Response Packet to a PC in File Mode after decoding a received Decode Command Packet.

6.3.3.3 Voice Data Packet Format

Voice Packet				
Bytes		16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	 7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
Header	0 - 1	0 0 0 0 0 0 0 0	1 1 0 1 1 0 1 0	len
	2 - 3	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 1	type
	4 - 5	x x x x x x x x	x x x x x x x x	seq
6 - 7		x x x x x x x x	x x x x x x x x	rate [0]
8 - 9		x x x x x x x x	x x x x x x x x	rate [1]
10 - 11		x x x x x x x x	x x x x x x x x	rate [2]
12 - 13		x x x x x x x x	x x x x x x x x	rate [3]
14 - 15		x x x x x x x x	x x x x x x x x	rate [4]
16 - 17		x x x x x x x x	1 1 0 0 x x x x	rate [5]
18 - 19		0 x 0 0 0 0 0 0	0 0 0 0 0 0 0 0	cmode
20 - 21		0 0 0 0 0 0 0 0	x x x x x x x x	tone.idx
22 - 23		x x x x x x x x	x x x x x x x x	tone.amp
24 - 25		0 0 0 0 0 0 0 0	1 0 x x x x x x	ws
26 - 27		0 0 0 0 x x x x	0 0 0 x 0 0 x x	format
28 - 29		x x x x x x x x	x x x x x x x x	voice [0]
30 - 31		x x x x x x x x	x x x x x x x x	voice[1]
32 - 33		x x x x x x x x	x x x x x x x x	voice [2]
…		…	…	…
346 – 350		x x x x x x x x	x x x x x x x x	voice[ws-1]

Table 30 Voice Data Packet

Voice Data Packets have the following format described Table 30 Voice Data Packet and C-language data structure below:

```
struct voice_packet_t {
       short     len;
       short    type;
       short     seq;

       short    rate[5];
       short   cmode;
       short    tone[2];
       short      ws;
       short  format;

       short   voice[160];
};
```

The size of the Voice Data Packet can vary depending on the number of samples in the `voice[]` buffer. The actual number of elements in the `voice[]` buffer can vary between 159 and 161. The nominal number of samples is 160. The `ws` and `len` elements of the Voice Data Packet should be adjusted to

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indicate the actual number of samples in `voice[]`. The elements of the Voice Data Packet are described in detail in the following sections.

6.3.3.4 Voice Data Packet Bytes 0 & 1 (len)

The len parameter (bytes 0 and 1) hold the 16-bit length of the packet (Table 3). The packet length can vary from 347 to 351 bytes.

len = *Length (in bytes) of total packet (including header)*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 0	Byte 1	Decimal Value
Data Packet Size	0 0 0 0 0 0 0 0	x x x x x x x x	347 - 351 bytes

Table 31 len Header Parameter

6.3.3.5 Voice Data Packet Bytes 2 & 3 (type)

The type parameter (bytes 2 and 3) is 16-bits packet type and is always 0x002 for voice data.

type = *Packet type*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	Hex Value
	Byte 2	Byte 3	
Voice Data	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 0	0x0002

Table 32 type Header Parameter

6.3.3.6 Voice Data Packet Bytes 4 & 5 (seq)

Bytes 4 and 5 hold the 16-bit sequence number (see Table 33). The sequence number is used as a method to detect if and when data packets are dropped, so it is important to ensure that consecutive sequence numbers are transmitted for channel data packets during operation.

seq = *Sequence number**			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 4	Byte 5	Decimal Value
Minimum Value	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	-32768
Maximum Value	0 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	32767

Table 33 seq Header Parameter

*Note: Sequence numbers should be incremented by one every time a packet is transmitted. When the sequence number reaches 32767, the next valid sequence number is -32768.

6.3.3.7 Voice Data Packet Bytes 6 to 17 (rate[0-5])

The rate[] array is used to indicate the vocoder type and is identical to the rate[] array in the Channel Data Packet discussed in section Channel Data Packet Bytes 6 to 17 (rate[0-5]).

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6.3.3.8 Voice Data Packet Bytes 18 & 19 (cmode)

The cmode element of the packet contains the input flags to the encoder when it is received by a VCU and the output flags of the decoder when it is transmitted from a VCU. The value of cmode also depends on the vocoder in use. Table 34 and Table 35 list the input flags to the encoder and the output flags of the decoder for the cmode element of Voice Data Packets.

cmode parameter			
Encoder Input Flags	16 bit Word 15 14 13 12 11 10 9 8 Byte 18	 7 6 5 4 3 2 1 0 Byte 19	Hex Value
AMBE_NS_ENABLE_FLAG	0 0 0 0 0 0 0 0	0 1 0 0 0 0 0 0	0x0040
HPITCH_DET_ENABLE_FLAG GMR-2+ Vocoder Only	0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0	0x0080
AMBE_FR_TONE_COMP_FLAG	0 0 0 0 0 0 1 0	0 0 0 0 0 0 0 0	0x0200
AMBE_DTX_ENABLE_FLAG	0 0 0 0 1 0 0 0	0 0 0 0 0 0 0 0	0x0800
AMBE_TONE_DET_ENABLE_FLAG	0 0 0 1 0 0 0 0	0 0 0 0 0 0 0 0	0x1000
AMBE_AGC_ON_FLAG APCO Enhanced Vocoder Only	0 0 1 0 0 0 0 0	0 0 0 0 0 0 0 0	0x2000
AMBE_DTMF_SEND_FLAG	0 1 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x4000

Table 34 cmode Parameter (Used in the Encoder Command Packet)

Table 34 cmode Parameter (Used in the **Encoder** Command Packet) shows the flags used to set various features of the encoder. For a description of what these flags see 4.9 Vocoder Options Configuration.

All the vocoders except the APCO Standard , when the AMBE_DTMF_SEND_FLAG is set to a 1 the encoder will ignore the voice data in the packet and send a tone. The index and amplitude of the tone is set in the tone.idx and tone.amp parameters of the Voice Data Packet (see Table 24 tone.idx Parameter and Table 25 tone.idx Parameter (cont'd)).

For the APCO Enhanced Vocoder if the AMBE_AGC_ON_FLAG is set, the automatic gain control is enabled and attempts to raise or lower the incoming voice level to maintain a constant level.

The value of AMBE_TONE_DET_ENABLE_FLAG is always set ON for the AMBE® / AMBE+™ encoder.

cmode parameter			
Decoder Output Flags	16 bit Word 15 14 13 12 11 10 9 8 Byte 18	 7 6 5 4 3 2 1 0 Byte 19	Hex Value
AMBE_VOICE_ACTIVE_FLAG	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 0	0x0002
AMBE_DATA_INVALID_FLAG	0 0 0 0 0 0 0 0	0 0 1 0 0 0 0 0	0x0020
AMBE_DTMF_FRAME_FLAG	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x8000

Table 35 cmode Parameter (Used in the Voice Response Packet)

All the vocoders except the APCO Standard decoder sets the AMBE_VOICE_ACTIVE_FLAG if the packet is not a silence frame. The AMBE_DATA_INVALID_FLAG is set by the decoder if the data that was received in the Channel Data Packet used to generate the Voice Data Packet was invalid, or if the Lost Frame or Mute flag was set in the cmode element of the Channel Data Packet. All the vocoders except the APCO Standard decoder sets the AMBE_DTMF_FRAME_FLAG if the packet contains a tone. The index and amplitude of the tone is set in the tone.idx and tone.amp parameters of the Voice Data Packet (see Table 24 tone.idx Parameter and Table 25 tone.idx Parameter (cont'd)).

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6.3.3.9 Voice Data Packet Bytes 20, 21, 22, 23 (tone.idx & tone.amp)

Values for tone.idx and tone.amp are the same as the tone.idx and tone.amp values for Channel Data Packets and are listed in Table 24 tone.idx Parameter and Table 25 tone.idx Parameter (cont'd). When tone signaling is inactive tone.idx should be set to NO TONE and tone.amp should be set to zero.

6.3.3.10 Voice Data Packet Bytes 24 and 25 (ws)

The ws element of the packet contains the number of voice samples that the Voice Data Packet contains. Values for ws are listed in Table 36 ws Parameter.

ws = Number of voice samples.			
Description	16 bit Word 15 14 13 12 11 10 9 8 Byte 24	7 6 5 4 3 2 1 0 Byte 25	Decimal Value
	0 0 0 0 0 0 0 0	1 0 0 1 1 1 1 1	159
	0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0	160
	0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 1	161

Table 36 ws Parameter

6.3.3.11 Voice Data Packet Bytes 26 and 27 (format)

The format element of the voice packet also indicates the format of the voice data in the voice[] array. Values for the voice data type in the format element is listed in Table 37 format Parameter.

format = Soft decision & *voice data*			
Voice Data Formats	16 bit Word 15 14 13 12 11 10 9 8 Byte 26	7 6 5 4 3 2 1 0 Byte 27	Hex Value
Linear 16-bit PCM	0 0 0 0 x x x x	0 0 0 0 0 0 0 0	0xXX00
a-Law	0 0 0 0 x x x x	0 0 1 0 0 0 0 1	0xXX21
u-Law	0 0 0 0 x x x x	0 0 0 1 0 0 0 1	0xXX11

Table 37 format Parameter

The voice data format to synthesize is as follows: The voice data to be synthesized is 16 bit PCM (format & 0x00ff) == 0x00

6.3.3.12 Voice Data Packet Bytes 28 to 346–350 (voice [0 to ws-1])

The number of elements in the voice[] array can vary between 159 and 161. The nominal number of elements should be 160. The voice format is 16 bit PCM. Each element of the voice array should contain one linear 16 bit voice sample.

Channel [192]			
Bytes	16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
…	…	…	…
28 - 29	x x x x x x x x	x x x x x x x x	voice [0-1]
30 – 31	x x x x x x x x	x x x x x x x x	voice [2-3]
32 – 33	x x x x x x x x	x x x x x x x x	voice [4-5]
…	…	…	…
346 – 350	x x x x x x x x	x x x x x x x x	voice [ws-1]

Table 38 voice Parameter

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6.3.4 Reset Packet

The Reset packet is used to reset the encoder and decoder state when the VCU is in File Mode. In order to get reproducible, bit-exact results in File Mode the state of the vocoder must be reset before sending Channel or Voice packets to the VCU.

Reset Packet				
Bytes		16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
Header	0 - 1	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	len
	2 - 3	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 1	type
	4 - 5	x x x x x x x x	x x x x x x x x	seq
6 – 7		0 0 0 0 0 0 0 0	0 0 0 0 0 0 x x	which

Table 39 Reset Packet

Reset packets have the following format described Table 39 Reset Packetand C-language data structure below:

```
struct reset_packet_t {
    short   len;
    short   type;
    short   seq;
    short   which;
};
```

The size of the Reset packet is eight bytes. The elements of the Reset packet are described in detail in the following sections.

6.3.4.1 Reset Packet Bytes 0 & 1 (len)

The len parameter (bytes 0 and 1) hold the 16-bit length of the packet (Table 3). The packet length is eight bytes.

len = *Length (in bytes) of total packet (including header)*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 0	Byte 1	Decimal Value
Reset Packet Size	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	8 bytes

Table 40 len Header Parameter

6.3.4.2 Reset Packet Bytes 2 & 3 (type)

The type parameter (bytes 2 and 3) is 16-bits packet type and is always 0x0000 for reset packets.

type = *Packet type*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	Hex Value
	Byte 2	Byte 3	
Reset	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x0000

Table 41 type Header Parameter

6.3.4.3 Reset Packet Bytes 4 & 5 (seq)

Bytes 4 and 5 hold the 16-bit sequence number (see Table 42). The sequence number is used as a method to detect if and when data packets are dropped, so it is important to ensure that consecutive sequence numbers are transmitted for channel data packets during operation.

seq = *Sequence number**			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 4	Byte 5	Decimal Value
Minimum Value	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	-32768
Maximum Value	0 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	32767

Table 42 seq Header Parameter

***Note:** Sequence numbers should be incremented by one every time a packet is transmitted. When the sequence number reaches 32767, the next valid sequence number is -32768.

6.3.4.4 Reset Packet Bytes 6 & 7 (which)

The which element is used to indicate which vocoder state to reset. If bit zero is set the encoder state is reset. If bit one is set the decoder state is reset. To reset both the encoder and decoder state set both bits zero and one.

which parameter			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 6	Byte 7	Hex Value
Encoder Reset	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1	0x0001
Decoder Reset	0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 0	0x0002

Table 43 which Parameter

6.3.5 Ack Packet

The Ack packet is used to acknowledge the Reset packet when the VCU is in File Mode.

Ack Packet				
Bytes		16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
Header	0 - 1	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	len
	2 - 3	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	type
	4 - 5	x x x x x x x x	x x x x x x x x	seq
6 – 7		0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	cmd

Table 44 Ack Packet

Ack packets have the following format described Table 44and C-language data structure below:

```
struct ack_packet_t {
    short    len;
    short   type;
    short    seq;

    short    cmd;
};
```

The size of the Ack packet is eight bytes. The elements of the Ack packet are described in detail in the following sections.

6.3.5.1 Ack Packet Bytes 0 & 1 (len)

The len parameter (bytes 0 and 1) hold the 16-bit length of the packet (Table 45). The packet length is eight bytes.

len = *Length (in bytes) of total packet (including header)*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 0	Byte 1	Decimal Value
Ack Packet Size	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	8 bytes

Table 45 len Header Parameter

6.3.5.2 Ack Packet Bytes 2 & 3 (type)

The type parameter (bytes 2 and 3) is 16-bits packet type and is always 0x0000 for ack packets.

type = *Packet type*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	Hex Value
	Byte 2	Byte 3	
Ack	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x0000

Table 46 type Header Parameter

6.3.5.3 Ack Packet Bytes 4 & 5 (seq)

Bytes 4 and 5 hold the 16-bit sequence number (see Table 47). The sequence number is used as a method to detect if and when data packets are dropped, so it is important to ensure that consecutive sequence numbers are transmitted for channel data packets during operation.

seq = *Sequence number**			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 4	Byte 5	Decimal Value
Minimum Value	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	-32768
Maximum Value	0 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	32767

Table 47 seq Header Parameter

***Note:** Sequence numbers should be incremented by one every time a packet is transmitted. When the sequence number reaches 32767, the next valid sequence number is -32768.

6.3.5.4 Ack Packet Bytes 6 & 7 (cmd)

The cmd element is used to indicate the packet type being acknowledged. Since Reset packets are the only packets acknowledged this value is always zero.

cmd parameter			
Packet Type Ack'ed	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 6	Byte 7	Hex Value
Reset	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0x0000

Table 48 cmd parameter

6.3.6 Nack Packet

The Nack packet is used to respond to badly formatted or unrecognized packets.

Nack Packet				
Bytes		16 bit Word 15 14 13 12 11 10 9 8 Byte (n)	7 6 5 4 3 2 1 0 Byte (n+1)	Parameter Name
Header	0 - 1	0 0 0 0 0 0 0 0	0 0 0 0 1 0 0 0	len
	2 - 3	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1	type
	4 - 5	x x x x x x x x	x x x x x x x x	seq
6 – 7		x x x x x x x x	x x x x x x x x	cmd
8 – 9		1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	reason

Table 49 Nack Packet

Nack packets have the following format described Table 49 and C-language data structure below:

```
struct nack_packet_t {
       short     len;
       short    type;
       short     seq;

       short     cmd;
       short  reason;
};
```

The size of the Nack packet is ten bytes. The elements of the Nack packet are described in detail in the following sections.

6.3.6.1 Nack Packet Bytes 0 & 1 (len)

The len parameter (bytes 0 and 1) hold the 16-bit length of the packet (Table 50). The packet length is ten bytes.

len = *Length (in bytes) of total packet (including header)*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 0	Byte 1	Decimal Value
Ack Packet Size	0 0 0 0 0 0 0 0	0 0 0 0 1 0 1 0	10 bytes

Table 50 len Header Parameter

6.3.6.2 Nack Packet Bytes 2 & 3 (type)

The type parameter (bytes 2 and 3) is 16-bits packet type and is always 0x0001 for nack packets.

type = *Packet type*			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	Hex Value
	Byte 2	Byte 3	
Nack	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1	0x0001

Table 51 type Header Parameter

6.3.6.3 Nack Packet Bytes 4 & 5 (seq)

Bytes 4 and 5 hold the 16-bit sequence number (see Table 52). The sequence number is used as a method to detect if and when data packets are dropped, so it is important to ensure that consecutive sequence numbers are transmitted for channel data packets during operation.

seq = *Sequence number**			
	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 4	Byte 5	Decimal Value
Minimum Value	1 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	-32768
Maximum Value	0 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	32767

Table 52 seq Header Parameter

***Note:** Sequence numbers should be incremented by one every time a packet is transmitted. When the sequence number reaches 32767, the next valid sequence number is -32768.

6.3.6.4 Nack Packet Bytes 6 & 7 (cmd)

The cmd element is used to indicate the packet type being Nack'ed.

cmd parameter			
Packet Type Nack'ed	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 6	Byte 7	Hex Value
Type	x x x x x x x x	x x x x x x x x	0xXXXX

Table 53 cmd Parameter

6.3.6.5 Nack Packet Bytes 8 & 9 (reason)

The reason element is used to indicate the reason for the Nack. This value is currently always 0xFFFF (invalid packet). Other values are reserved for future expansion.

cmd parameter			
Packet Type Nack'ed	16 bit Word 15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
	Byte 8	Byte 9	Hex Value
Packet Invalid	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1	0xFFFF

Table 54 reason Parameter

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7 VCU Specifications

This section contains hardware Specifications of the VCU. Any interfaces listed as "inactive" require firmware and software upgrades to activate. NOTE: All values are typical unless noted otherwise. All specifications subject to change.

7.1 Rear Panel Connections

Serial Port	
Type	RS-232
Connector	DE9s

Net-2000™-VCU RS 232 Serial Port Pin Out (as view from the back of the unit)	
Pin Number	Name
1, 4, 6	Connected together internally
2	Tx
3	Rx
5	Ground
7	CTS
8	RTS
9	No Connection

Table 55 Serial Port Pin Outs

LAN	
Type	10-BaseT Ethernet
Connector	RJ-45

RS-422 Synchronous	
Type	RS-422 differential
Connector	DB-15HD

Net-2000™-VCU RS 422 Synchronous Serial Port Pin Out (as view from the back of the unit)		
Pin Number	Description	Polarity
1	CLK_RX	negative
2	CLK_RX	positive
3	FS_RX	positive
4	RX	positive
5	CLK_TX	negative
6	FS_TX	negative
7	TX	negative
8	GND	
9	NC	
10	FS_RX	negative
11	RX	negative
12	GND	
13	CLK_TX	positive
14	FS_TX	positive
15	TX	positive

Table 56 RS-422 Synchronous Serial Port Pin Outs

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RS-422 Asynchronous	
Type	RS-422 differential
Connector	RJ-45

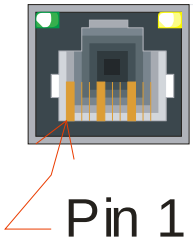

Figure 33 RS-422 Asynchronous Pin 1

Two Net-2000™-VCU units can be connected together using the RS-422 Asynchronous connection and a crossover CAT5 cable.

Net-2000™-VCU RS 422 Asynchronous Serial Port Pin Out (as view from the back of the unit)		
Pin Number	Description	Polarity
1	Tx	positive
2	Tx	negative
3	Rx	positive
4	NC	
5	NC	
6	Tx	negative
7	NC	
8	NC	

Table 57 RS-422 Asyncronous Serial Port Pin Outs

7.2 Audio I/O Connections

2-Wire	
Analog 2 Wire	Input / Output:
Type:	Deferential
Connector:	RJ-11 6P2C
Input /Output Impedance:	600 Ohms
Bandwidth:	300 Hz to 3300 Hz
A/D,D/A Resolution:	16 bits
A/D,D/A Sampling Rate:	8 kHz

Line In	
Type	Single-ended 4 Wire Input
Connector	female RCA
Maximum Input Level:	+/- 2.45 Volts
Input Impedance	10 kOhms
Bandwidth	20 Hz to 4 kHz
D/A Resolution	16 bits
D/A Sampling Rate	8 kHz

Note: A 1.414 V signal on the line input produces digital max when the codec input gain is 0 dB.

Line Out	
Type:	Single-ended 4 Wire Output
Connector:	female RCA
Maximum Output Level	+/- 1.5 Volts
Output Impedance:	<10 Ohms
Bandwidth:	20 Hz to 4 kHz
A/D Resolution:	16 bits
A/D Sampling Rate:	8 kHz
Minimum Load	600 Ohms

Note: A digital max produces 1.414 V signal on the line output when the codec output gain is 0 dB.

Handset:	
Type:	Single-ended
Connector:	RJ 4P4C
Bandwidth:	20 Hz to 4 kHz
A/D Sampling Rate:	8 kHz
A/D Resolution:	16 bits

7.3 Electrical Input

AC Power	
Input Voltage	110/220 Volts AC
Input Current	@ 110V AC 250 ma
Input Current	@ 220V AC 125 ma
Rated Input Frequency	50/60 Hz

7.4 Mechanical

Mechanical	
Weight	4.25 lbs.
Size (W X D X H)	17.25”X7.25”X3.5”

7.5 Environmental

Environmental	
Operating Temperature	5 to 35 degrees C
Humidity	5 to 80% RH non-condensing
Storage Temperature	-20 to 60 degrees C

8 Upgrade Procedure

Future upgrades to the Net-2000™-VCU's internal software may become available to provide for additional features and capabilities or to remedy unforeseen issues. In order to upgrade the Net-2000™-VCU's internal software the following equipment is required.

A PC (Windows OS) with network access to the same LAN the VCU is on, and a terminal connected to the VCU console serial port.

The VCU upgrade image file located on a shared folder on the PC

First. Telnet to the VCU. Open a DOS window and telnet to the VCU using its IP address or host name:

```
telnet 192.168.1.100
```

Next, at the adsh> prompt of the VCU console shell, give the VCU access to the shared folder by typing the following commands:

```
adsh>mkdir /var/upgrade
adsh>smbmount //<host_name>/<share_directory> /var/upgrade -U<user> -
P<password>
```

where <host_name> is the PC's host name and <share_directory> is the name of the shared folder.

Be sure the shared folder on your PC does not require require a user name and password to gain access. When adding -U<user> and -P<password> to the smbmount command the <user> can be any user name and <password> can be any password.

> Note: The mount only works when using the host_name not the IP address. Also, there is no space between `-U and` <user> or `–P and` <password>

Now change directories to the shared folder on the PC and download the upgrade:

```
adsh>cd /var/upgrade
adsh>cat <imagefile> | flash - /dev/all
```

where <imagefile> is the file name of the upgrade image. After the upgrade is loaded into the VCU, reboot it with the following command.

adsh>shutdown

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9 Support

9.1 DVSI Technical Support

If you have any problems with the Net-2000™-VCUVoice Codec Unit or have questions about its operation, please contact:

Digital Voice Systems, Inc.
234 Littleton Road
Westford, MA 01886 USA

Phone: (978) 392-0002
Fax: (978) 392-8866

email: **mailto:info@dvsinc.com**
web: **http://www.dvsinc.com/**

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10 History of Revisions

History of Revisions			
Version Number	Date of Revision	Description	Pages
3.0	Feb. 2010	Revised format of manual	all
3.1	April 2010	Added Note	23
3.2	April 2011	Edited tables 7 through 58	
3.3	April 2013	Edited applicable patent list in the end user lisence agreement section	iii
4.0	Dec. 2013	Added in GMR-2+ and BGAN vocoders information	various

11 Notes

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